TAB J
PART 10

Fig. 13

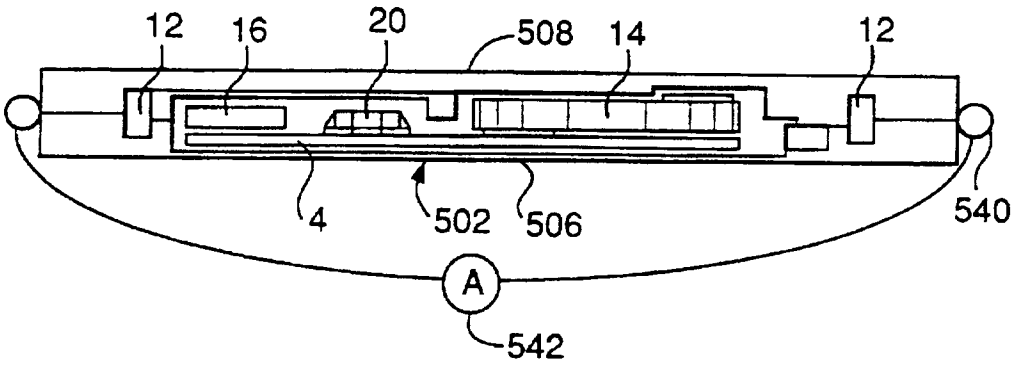


Fig. 14

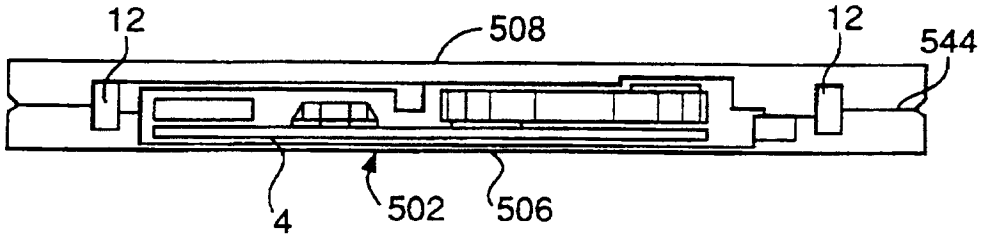


Fig. 15

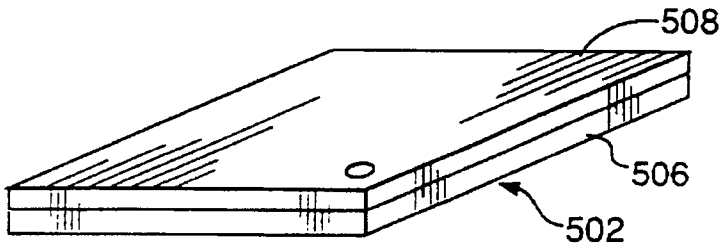
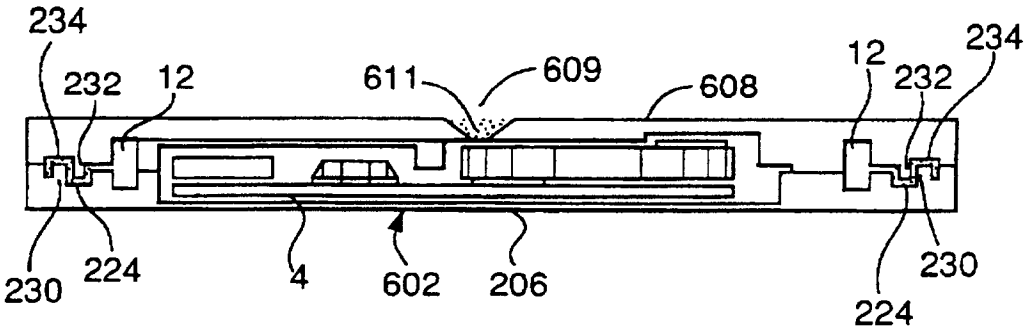

508
506
502

Fig. 16


234
232
12
611
609
608
12
232
234
230
224
4
602
206
230
224

IC CARD

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an IC card and a fabrication method therefor, in particular to an IC card which transmits data with electromagnetic waves and a fabrication method therefor.

2. Description of the Prior Art

An IC card includes a module constructing an electric circuit including integrated circuits and electronics parts. The module is arranged in an internal space between base and cover panel members. An IC card used for example in a ski resort transmits data with electromagnetic waves. Such an IC card is fabricated so that the two panel members are connected to each other with an adhesive along the whole peripheral thereof to keep the IC card airtight.

When such an IC card is fabricated, the two panel members are combined with each other with a thermosetting adhesive agent applied between them and the adhesive agent is cured by heating. Thus, the inside of the IC card is shielded by the adhesive agent. However, when the two panel members combined with an adhesive agent are put in a thermostat, the gas inside the IC card expands and presses the gas inside the IC card towards the outside. As a result, an actual adhesion area becomes narrower than required, and this weakens the mechanical strength of the IC card or the panel members may separate from each other.

Further, portions not adhered between the two panel members are liable to occur, and if such portions exist, the IC card is exposed to ambient environment through these portions, and moisture or water permeates inside the IC card, and this corrodes the module causing malfunctions.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an IC card having a sufficient adhesion strength and a fabrication method therefor.

Another object of the present invention is to provide an IC card having airtight adhesion with no leak paths to the outside thereof and a fabrication method therefor.

An IC card comprises a first panel member, a second panel member and a module constructing an electric circuit arranged between the two panel members. The IC card is kept airtight in various ways. In one aspect of the invention, the first panel member has a groove along a periphery thereof, while a second panel member has a protrusion to engage with the groove of said first panel member. The groove has a distribution of width (preferably portions of a narrower width and portions of a wider width arranged alternately). Thus, spaces are left between an inner peripheral of the groove of the first panel member and the protrusion of the second panel member. Then, when the IC card is fabricated by heating a thermosetting adhesive agent between the groove and the protrusions, the adhesive can remain in the spaces while fills passages of expanded gas in the inner space of the IC card due to viscosity.

In a second aspect of the invention, a first panel member has a groove, while a second panel member has a protrusion to engage with the groove of the first panel member, the protrusion having an edge along the whole groove, the edge making contact with a bottom of the groove of the first panel member when the groove is engaged with an adhesive agent with the protrusion. The edge makes close contact with the bottom of the groove, and the inner space in the IC card is kept airtight.

In a third aspect of the invention, an adhesion agent fills all the inner space between the first panel member and the second panel member. Because there is no gas in the inner space, there is no adverse influence of the gas on curing the adhesive agent.

In a fourth aspect of the invention, an adhesion member applied between the groove of the first panel member and the protrusion of the second panel member is made of an acrylic adhesive agent having a viscosity larger than or equal to 10^8 cp. Then, even if the temperature of the adhesion member is increased, the adhesion member does not move from the groove towards the outside.

In a fifth aspect of the invention, when an IC card is fabricated, a thermosetting adhesive is applied to an outer portion on the first panel member so as to occupy the inner space at a ratio equal to or larger than (T_1/T_0-1) of volume, wherein T_1 denotes an absolute temperature in the thermostat and T_0 denotes absolute room temperature. Then, the combined first and second panel members is put in a thermostat to cure the adhesive agent, the adhesive agent remains in the groove, and the IC card is kept airtight.

In a sixth aspect of the invention, a first panel member with an adhesive agent applied is put first in a thermostat. Then, the first panel member is combined with a second panel member in the thermostat. Then, there is no pressure difference between the inner space of the IC card and the outside when the adhesive agent is cured.

In a seventh aspect of the invention, after mounting a module constructing an electric circuit on a first panel, the first panel member is combined with a second panel member with a contact plane between them. Then, the first and second panel members are heated along the whole peripheral thereof to melt the first and second panel members at the contact plane. Thus, the two panel members are adhered without expanding the gas in the inner space.

An advantage of the present invention is that the IC card has a sufficient mechanical strength because the adhesion area has a prescribed value.

Another advantage of the present invention is that the IC card does not cause a malfunction due to water penetration in to the inside of the IC card.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, and in which:

FIG. **1** is a plan view of an IC card of a first embodiment of the invention with a cover removed;

FIG. **2** is a sectional view of the IC card along A—A line in FIG. **1**;

FIG. **3** is a flowchart of fabrication of the IC card;

FIG. **4** is a graph of temperature dependence of viscosity on curing;

FIG. **5** is a plan view of an IC card of a second embodiment of the invention with a base removed;

FIG. **6** is a partial sectional view of the IC card along B—B line in FIG. **5**;

FIG. **7** is a plan view of an IC card of a third embodiment of the invention with a cover removed;

FIG. **8** is a sectional view of the IC card along C—C line in FIG. **7**;

FIG. **9** is a sectional view of an IC card of a fourth embodiment of the invention;

FIG. **10** is a sectional view of an IC card of a fifth embodiment of the invention;

FIG. **11** is a graph of temperature dependence of viscosity on curing;

FIG. **12** is a flowchart of fabrication of the IC card;

FIG. **13** is a sectional view of an IC card in a process for fabricating it;

FIG. **14** is a sectional view of an IC card of a seventh embodiment of the invention;

FIG. **15** is a perspective view of an IC card of the seventh embodiment of the invention; and

FIG. **16** is a sectional view of an embodiment of an IC card.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein like reference characters designate like or corresponding parts throughout the drawings, FIGS. **1** and **2** show an IC card **2** of a first embodiment of the invention. As shown in FIG. **2**, the IC card includes a module **4** constructing an electric circuit, a base **6** and a cover **8**. The base **6** and the cover **8** are made with resin, and they are integrated to form a panel. They are adhered with an adhesive agent **10** along an entire periphery thereof and includes the module **4** in an internal space formed between them. A coil **12** (only a groove therefor is shown in FIGS. **1** and **2**) for receiving data are arranged between the base **6** and the cover **8**.

FIG. **1** shows the IC card **2** in a state with its cover **8** removed. The module **4** includes an electric circuit constructed by mounting, for example, a cell **14**, an integrated circuit **16**, a ceramic oscillator **18**, a capacitor **20** and a resistor **22**. The base **6** has a groove **24** for applying a liquid adhesive agent **10** outside the groove for the coil **12**. The groove **24** is located continuously along the outer peripheral of the base **6**. It is a feature that the groove **24** has a width which is not uniform, including portions **26** having a wider width than the remaining portions at prescribed intervals along the whole groove **24**. In the example shown in FIG. **1**, the portions **26** having a wider width and portions **28** having a narrower width are provided alternately at equal intervals. The portions **26** and **28** are also provided at the four corners of the base **6** though the widths are different from the counterparts along the four sides thereof. Further, a protrusion **30** is provided outside the groove **24**. On the other hand, the cover has a protrusion **32** to be engaged with the groove **24** of the base **6** and a recess **34** in correspondence to the protrusion **30** of the base **6**. The protrusion **32** has a width in correspondence to the width of the portions **26** having the narrower width, and there remain spaces between the inner circumference of the portions **28** and the protrusion **32** when the groove **24** is engaged with the protrusion **32**.

Next, fabrication of the IC card **2** is explained with reference to FIG. **3**. First, the module **4** and the base **6** are provided. Next, the module **4** and the coil **12** are mounted to the base **6**. Then, the cover **8** is provided, while the adhesive agent **10** is applied to the groove **24** of the base **6** and the protrusion **32** of the cover **8**. Next, the groove **24** of the base **6** is engaged with the protrusion **32** of the cover **8**, to mount the cover **8** to the base **6**. Then, the combined unit is put into a thermostat, and the temperature in the thermostat is increased to set the adhesive agent.

FIG. **4** shows the time dependence of the viscosity of the adhesive agent **10** after the combined unit is put into the thermostat or in an environment to cure the adhesive agent.

The viscosity increases with increasing temperature gradually. When the temperature exceeds the setting temperature of the adhesive agent, the viscosity starts to increase sharply and the adhesive agent becomes a solid or rubber-like material.

In the fabrication of the IC card, when the combined unit is put in the thermostat, gas inside the IC card **2** expands due to temperature increase, and it leaks through the groove **24** to the external. Passages or leakage paths of the gas are likely to be formed at the portions **28** having a narrower width (except the portions **26** storing the excess adhesive agent **10**) because the width of the groove **24** has a distribution. Then, there is no pressure difference between the inside and the outside of the IC card. On the other hand, a large amount of the adhesive agent gathers in spaces between the inner circumference of the portions **28** and the protrusion **32**. After the passages are formed, the adhesive agent gathering in the portions **26** flows into the passages to fill the passages due to its viscosity. A proper amount of the adhesive agent **10** is needed to serve this function. Then, the adhesive agent **10** is cured or solidified in a state where there is no pressure difference between the inside and the outside of the IC card **2**.

As explained above, because the groove **24** has a distribution of width, passages are formed deliberately between the inside and the outside of the IC card, there is no pressure difference on curing, and no adhesive agent flows outside. Further, the portions **26** having a wider width serves as a source for supplying the adhesive agent to the passage. Therefore, a desired adhesive area can be obtained. Then, because no water or moisture leaks into the inside, no malfunction of the IC card **2** occurs.

FIGS. **5** and **6** shows an IC card **102** of a second embodiment of the invention. As shown in FIG. **6**, the IC card **102** comprises a module **4** constructing an electric circuit, a base **106** and a cover **108**, similar to the IC card **2** of the first embodiment. The base **106** and the cover **108** are made with resin, and they are integrated to form a panel. They are adhered with an adhesive agent **110** along an entire periphery thereof and include the module **4** in an internal space formed between them. A coil **12** (only a groove therefor is shown in FIG. **5**) for receiving data is arranged between the base **106** and the cover **108**. The base **106** is different from the base **6** of the first embodiment in that the groove **124** for applying the adhesive agent **110** has a uniform width along the whole circumference and that the cover **108** has a protrusion **134** with an edge **133**.

When the base **106** is combined with the cover **108** by applying the adhesive agent **110** at the groove **124** and the protrusion **134**, the edge **133** of the protrusion **134** engages with the groove **124** to keep the space between the base **106** and the protrusion **108** airtight. Therefore, when the combined unit of the cover **108** and the base **106** is put in a thermostat for curing, the edge **133** makes contact closely with the groove **124** and the expansion of the gas is suppressed by the edge **133**, and no adhesive agent flows out through the space between the edge **133** and the groove **124**. Therefore, a desired adhesive area can be obtained. Then, because no water or moisture leaks into the inside, no malfunction of the IC card **102** occurs.

FIGS. **7** and **8** show an IC card **202** of a third embodiment of the invention. As shown in FIG. **8**, the IC card **202** comprises a module **4** constructing an electric circuit, a base **206** and a cover **208**, similar to the IC card **2** of the first embodiment. The base **206** and the cover **208** is made with resin, and they are integrated to form a panel. They are

adhered with an adhesive agent **210** along periphery thereof and includes the module **4** in an internal space formed between them. A coil **12** (only a groove therefor is shown in FIG. **8**) for receiving data are arranged between the base **206** and the cover **208**. The base **206** is different from the base **6** of the first embodiment in that the groove **224** for applying an adhesive agent **110** has a uniform width along the whole circumference and that the cover **208** has a protrusion **232** in correspondence to the groove **224**.

In FIG. **7**, the adhesive **210** are applied in a region **211** illustrated with dots. The region **211** has a volume equal to or larger than a ratio of (T_1/T_0-1) of the whole internal space V_0 between the base **206** and the cover **208**, wherein T_1 denotes an absolute temperature in the thermostat and T_0 denotes absolute room temperature. The region **211** is explained further. According to the equation of state of ideal gas,

$$pV=nRT, \quad (1)$$

where p denotes pressure, V denotes volume, n denotes a mol number, R denotes gas constant and T denotes temperature expressed in the unit of absolute temperature.

$$pV_1=nRT_1, \quad (2)$$

where V_1 denotes the volume of the gas in the inner space between the base **206** on curing and the cover **208** and T_1 denotes the curing temperature. Then, the following relation holds:

$$V_1T_1=V_0/T_0=nR/p, \quad (3)$$

where V_0 denotes the volume of the gas in the inner space between the base **206** at room temperature and the cover **208** and T_1 denotes room temperature. Therefore,

$$V_0=(T_0/T_1)V_1. \quad (4)$$

That is, the volume change depends of a temperature ratio T_0/T_1.

When the IC card **202** is fabricated, the adhesive agent **210** is applied in the region **211** to enclose a gas in the inner space in the IC card **202** so that the volume V_1 on the curing temperature T. is smaller than the whole inner space enclosed by the base **206** and the cover **208**. Then, though the gas expands by heating and presses the adhesive agent **210** to the outside, it does not go out from the inner space, or the adhesive agent exists in the groove **224** for strong adhesion A lower limit of the adhesive agent **210** applied in the region **211** is given by a following relation:

$$V_1-V_0=(T_1/T_0-1)V_0. \quad (5)$$

In a fabrication process, the adhesive agent **210** is applied in the peripheral region **211** on the base **206** to enclose a gas in the inner space in the IC card **202**, and it occupies a volume equal to or larger than a ratio of (T_1/T_0-1) of the whole internal space V_0 between the base **206** and the cover **208**. Then, the base **206** is combined with the cover **208** so as to engage the groove **224**, a desired adhesive area can be obtained with the protrusion **232**, and the combined unit is put in a thermostat. Then, the gas in the inner space expands due to the temperature difference at the inner space, but the adhesive agent **210** remains in the groove **224** on curing. Therefore, there occurs no passage of gas at the groove **224**, and a desired adhesive area can be obtained. Then, because no water or moisture leaks into the inside, no malfunction of the IC card **202** occurs.

FIG. **9** shows an IC card **302** of a fourth embodiment of the invention. The IC card **302** is the same as the IC card **202** of the third embodiment except that an adhesive agent **310** fills all the inner space between a base **306** and a cover **308**. When the IC card **302** is fabricated, after the adhesive agent **310** (illustrated with dots in FIG. **9**) fills all the inner space so as to exclude all the gas in the inner space, a combined unit of the base **306** and the cover **308** is put in a thermostat for curing the adhesive agent **310**.

There is no gas in the inner space. Therefore, no gas expansion occurs in the inner space on curing or the adhesive agent **310** is not pressed towards the outside, so that a desired adhesive area can be obtained. Then, because no water or moisture leaks into the inside, no malfunction of the IC card **302** occurs.

FIG. **10** shows an IC card **402** of a fifth embodiment of the invention. The IC card **402** is the same as the IC card **202** of the third embodiment except an adhesive agent **410** provided between a groove **224** of a base **206** and a protrusion **232** of a cover **208**. The adhesive agent **410** includes an acrylic adhesive agent having a viscosity equal to or larger than 10_8 cp. Therefore, the adhesive agent **410** does not flow even when the pressure in the inner space of the IC card **402** increases due to a temperature increase during curing. FIG. **11** shows an example of the viscosity characteristic of an epoxy acrylic adhesive agent. The viscosity is kept the same after a combined unit of the base **206** with the cover **208** is put in a thermostat. When curing starts, the viscosity increases, and the adhesive agent **410** becomes a solid or a rubber-like material. Then, no gas expansion occurs in the inner space on curing or the adhesive agent **410** remains in the groove **224**, so that a desired adhesive area can be obtained. Then, because no water or moisture leaks into the inside, no malfunction of the IC card **402** occurs.

Next, a fabrication method of a sixth embodiment of the invention is explained with reference to FIG. **12**. The IC card to be fabricated is the same as that **202** of the third embodiment (FIGS. **7** and **8**) except an amount of the adhesive agent **210**. First, the module **4** (including the coil **12**) and the base **206** are provided. Next, the module **4** and the coil **12** is mounted to the base **206**. Then, before the cover **208** is mounted, the adhesive agent **210** is applied to the groove **224** of the base **206**. Next, the cover **208** is provided, while the base **206** is put in an curing environment in a thermostat, and the groove **224** of the base **206** is engaged with the protrusion **230** of the cover **208**, to combine the base **206** with the cover **208**. Because there is no temperature difference between the inside and the outside of the inner space between the base **206** and the cover **208**, when the cover **208**, is mounted to the base **206**, no gas expansion occurs, or the adhesive agent **210** is not pressed towards the outside. Then, the adhesive agent **210** is set, and a desired adhesive area can be obtained.

FIGS. **13** and **14** shows an IC card **502** of a seventh embodiment of the invention. The IC card **502** is similar to the IC card **202** (FIGS. **7** and **8**) of the third embodiment except that no adhesive agent is used. Because no adhesive agent is used, a base **506** and a cover **508** do not have the groove **224** for applying an adhesive agent, the protrusion **230** to be engaged with the groove **224**, the protrusion **232** and the groove **234**. On the other hand, the base **506** and the cover **508** have a contact plane between them at least at and

near a side of the IC card, and they are adhered at the contact plane. The IC card **502** comprises a module **4** constructing an electric circuit, a base **506** and a cover **508**. The base **506** and the cover **508** are made with resin, and they are integrated to form a panel. In the fabrication of the IC card **502**, after the module **6** and the coil **12** are mounted to the base **506** and the cover **508** is combined with the base **506**, a heater **540** is wound along an adhesion line at the outer periphery of the contact plane between the base **506** and the cover **508** of the combined unit. A power supply **542** is connected to the heater **540**, and an electric current is supplied to the heater **540** to increase the temperature of at the adhesion line up to a melting temperature of the base **506** and the cover **508**. Then, a melted section **744** is formed along the whole circumference to close the inner space between the base **506** and the cover **508**. FIG. **15** shows a perspective view of the completed IC card.

Because the entire IC card **502** is not heated in the above-mentioned fabrication method, the gas inside the inner space does not expand and a desired adhesive area can be obtained. Because no water or moisture leaks into the inside, no malfunction of the IC card **402** occurs.

FIG. **16** shows another IC card **602** closing the inner space. The IC card **602** is the same as the IC card **202** of the third embodiment (FIGS. **7** and **8**) except a cover **608** having a throughhole **609** as a vent hole. The IC card **602** comprises a module **4** constructing an electric circuit, a base **206** and a cover **608**. The base **206** and the cover **608** are made with resin, and they are integrated to form a panel. In the fabrication of the IC card **602**, after the module **6** and the coil **12** are mounted to the base **206**, the cover **608** is combined with the base **206** with an adhesive agent **210** applied at a groove **224**. Then, the combined unit is put in a thermostat for curing the adhesive agent **210**. After the curing of the adhesive agent **210**, the combined unit is put in an ambient environment, and the hole **609** is filled with a sealant **611** such as a silicone rubber which will sets at room temperature. On curing, the expanded gas leaks through the hole **609**, and the adhesive agent **210** is not pressed towards the outside so that a desired adhesive area can be obtained. Because the hole **609** is sealed after curing, no water or moisture enters into the IC card **602**, and no malfunction of the IC card **302** occurs.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

What is claimed is:

1. An IC card comprising:

a first panel member having a groove along a periphery thereof, the groove having a non-uniform width distribution;

a second panel member having a protrusion to engage the groove of said first panel member, wherein spaces are formed between an inner periphery of the groove of said first panel member and the protrusion of said second panel member;

a module arranged in an internal space between said first and second panel members; and

an adhesion member cured between the groove of said first panel member and the protrusion of said second panel member.

2. The IC card of claim **1**, wherein the groove having the varying width distribution, the adhesion member, and the protrusion interact to fully adhere said first panel member to said second panel member.

3. The IC card of claim **1**, wherein the groove having the varying width distribution, the adhesion member, and the protrusion interact to prevent pressure build-up inside said IC card.

4. The IC card of claim **1**, wherein the groove having the varying width distribution, the adhesion member, and the protrusion interact to provide an airtight bond between said first panel member and said second panel member.

5. An IC card comprising:

a first panel member having a groove along a periphery thereof, the groove having a width distribution;

a second panel member having a protrusion to engage the groove of said first panel member, wherein spaces are formed between an inner periphery of the groove of said first panel member and the protrusion of said second panel member;

a module arranged in an internal space between said first and second panel members; and

an adhesion member cured between the groove of said first panel member and the protrusion of said second panel member;

wherein the groove of said first panel member includes first sections having a first width and second sections having a second width, wider than the first sections, the first sections and the second sections being arranged alternately.

6. The IC card of claim **5**, wherein the groove having the varying width distribution, the adhesion member, and the protrusion interact to fully adhere said first panel member to said second panel member.

7. The IC card of claim **5**, wherein the groove having the varying width distribution, the adhesion member, and the protrusion interact to prevent pressure build-up inside said IC card.

8. The IC card of claim **5**, wherein the groove having the varying width distribution, the adhesion member, and the protrusion interact to provide an airtight bond between said first panel member and said second panel member.

9. An IC card comprising:

a first panel member having a groove along a periphery thereof;

a second panel member having a protrusion to engage the groove of said first panel member, the protrusion including an edge making linear contact with a bottom of the groove of said first panel member along an entire length of the groove;

a module arranged in an internal space between said first and second panel members; and

an adhesion member cured between the groove of said first panel member and the protrusion of said second panel member.

10. The IC card of claim **9**, wherein the protrusion is triangular in shape.

11. The IC card of claim **9**, wherein the groove having the varying width distribution, the adhesion member, and the protrusion interact to fully adhere said first panel member to said second panel member.

12. The IC card of claim **9**, wherein the groove having the varying width distribution, the adhesion member, and the protrusion interact to suppress expansion of a gas inside said IC card.

13. The IC card of claim **9**, wherein the groove having the varying width distribution, the adhesion member, and the protrusion interact to provide an airtight bond between said first panel member and said second panel member.

* * * * *

US005774339A

United States Patent [19]

Ohbuchi et al.

[11] **Patent Number: 5,774,339**

[45] **Date of Patent: Jun. 30, 1998**

[54] **IC CARD AND METHOD OF MAKING THE SAME**

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[73] Assignee: **Mitsubishi Denki Kabushiki Kaisha**, Tokyo, Japan

[21] Appl. No.: **759,002**

[22] Filed: **Dec. 2, 1996**

[30] **Foreign Application Priority Data**

May 30, 1996 [JP] Japan 8-136599

[51] **Int. Cl.**[6] **H05K 1/14**

[52] **U.S. Cl.** **361/737**; 361/740; 361/747; 361/759; 235/380

[58] **Field of Search** 361/736, 737, 361/740, 741, 742, 745, 747–749, 752–754, 756, 758–759, 770, 801–803, 820; 235/380, 492, 441, 435, 487; 264/272.11, 272.14, 274, 275; 29/846, 855–856

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Primary Examiner—Leo P. Picard
Assistant Examiner—Phuong T. Vu

[57] **ABSTRACT**

An IC card includes a first cover including a first flat panel portion and a first upright wall portion formed therein adjacent a perimeter of the flat panel portion so as to extend transverse to the flat panel portion, and a second cover including a second flat panel portion and a second upright wall portion formed therein adjacent a perimeter of the flat panel portion so as to extend transverse to the flat panel portion. The first upright wall portion defines a chamber in cooperation with a portion of the first flat panel portion. The first and second covers are mated together with the first and second upright wall portions bonded together in a butt fashion.

6 Claims, 3 Drawing Sheets

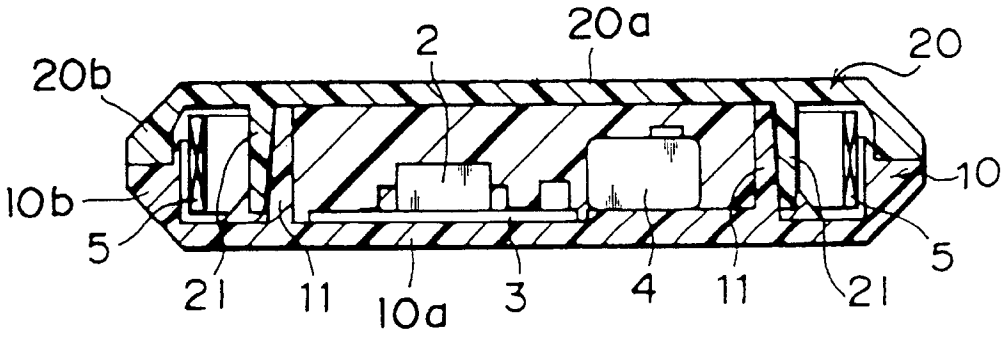


Fig. 1

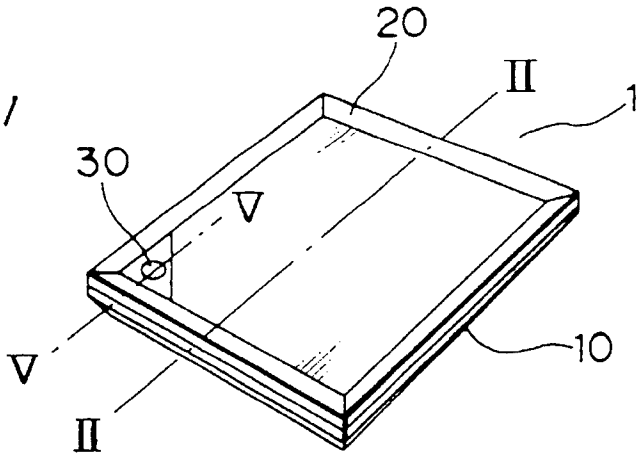


Fig. 2A

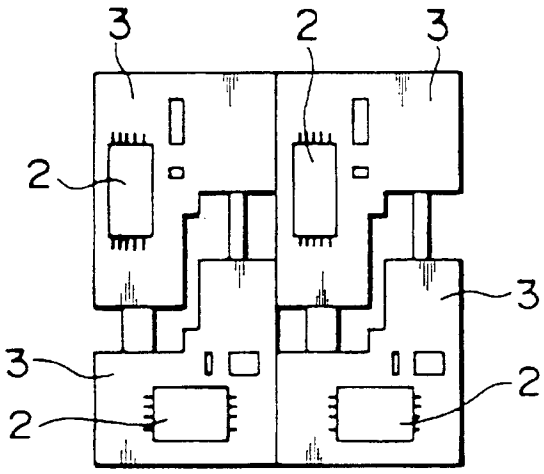


Fig. 2B

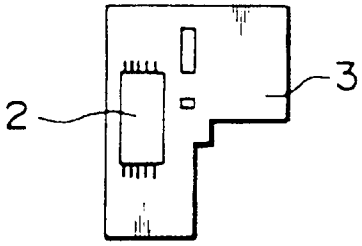


Fig. 2C

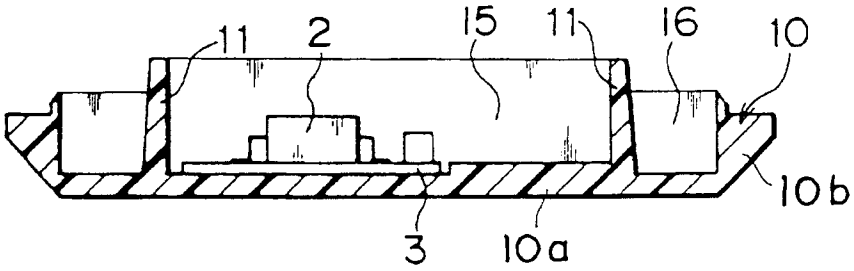


Fig. 2D

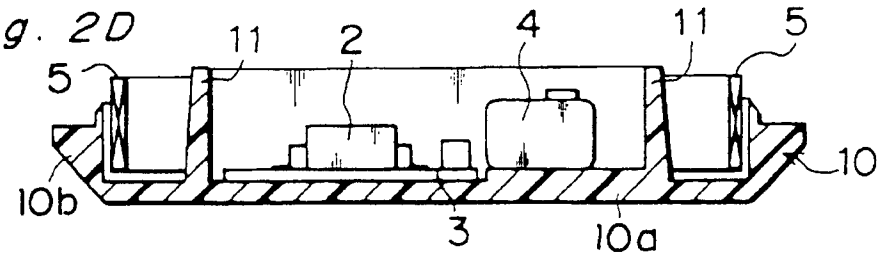


Fig. 2E

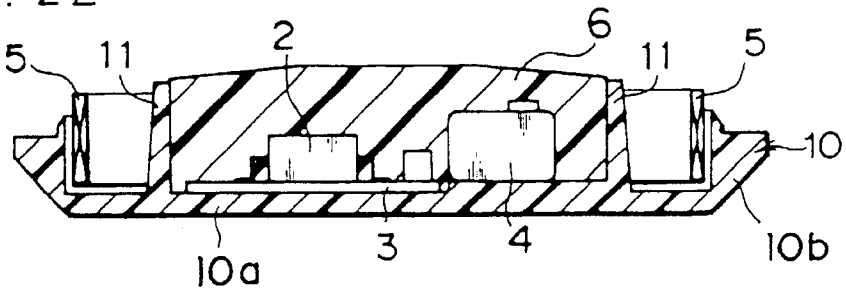


Fig. 2F

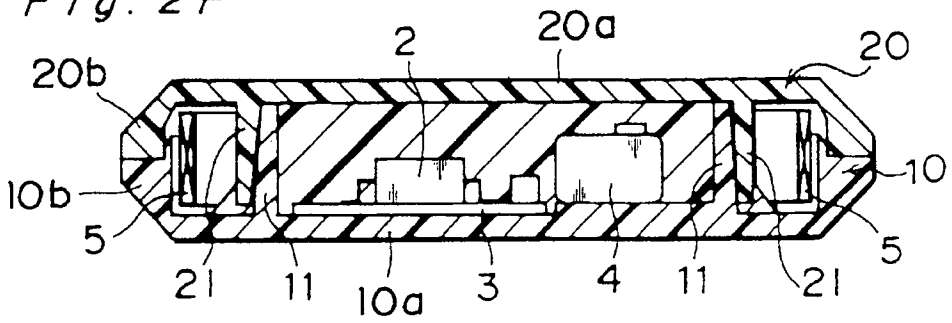


Fig. 3

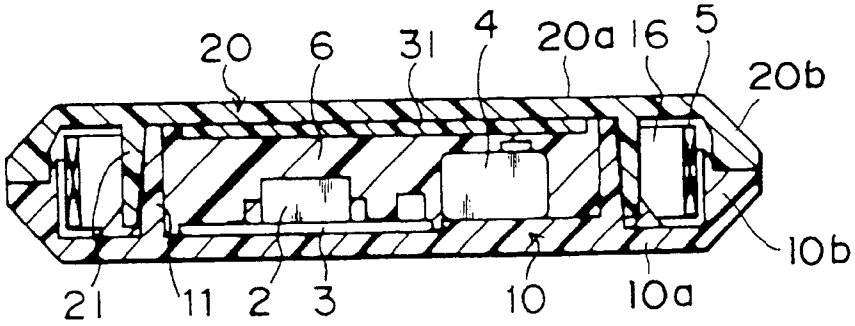


Fig. 4

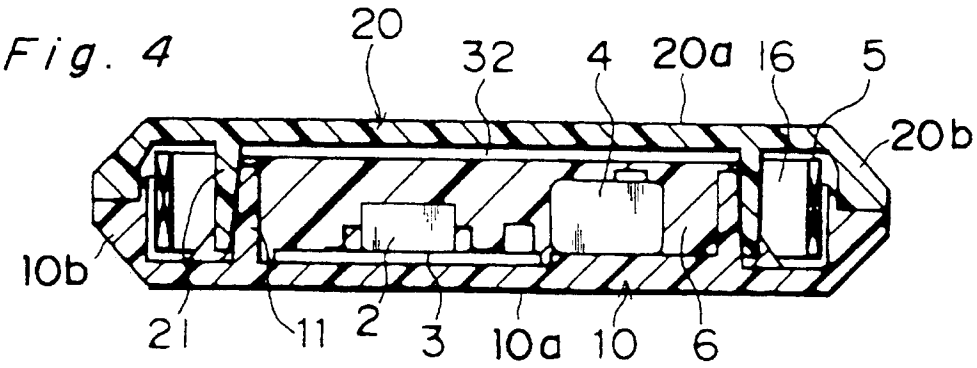


Fig. 5

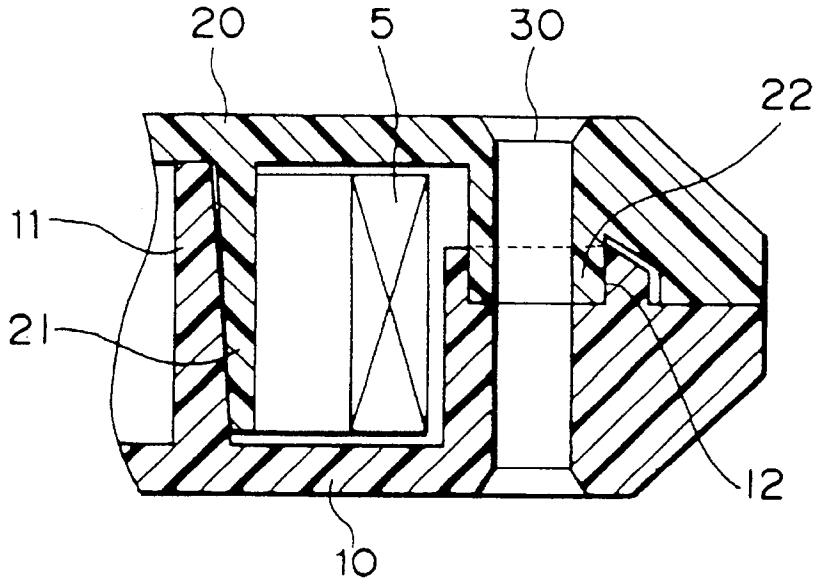
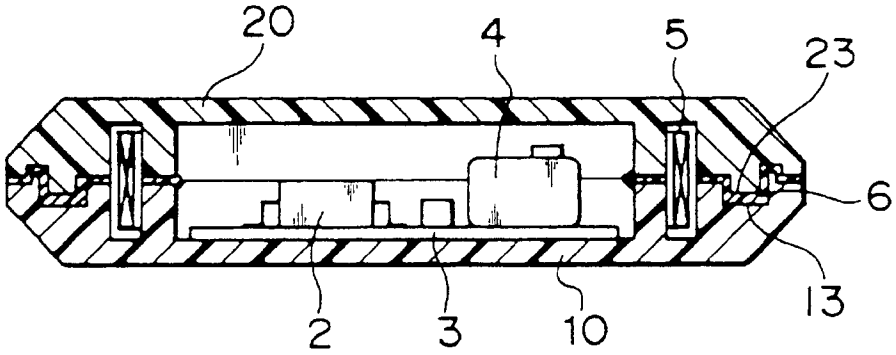


Fig. 6 PRIOR ART



IC CARD AND METHOD OF MAKING THE SAME

BACKGROUND OF THE INVENTION

1. (Field of the Invention)

The present invention generally relates to an IC card and, more particularly, to the IC card of a non-contact type which has no interfacing terminal electrode exposed to the outside, but utilizes wireless signals such as electromagnetic waves for communication with external system appliances.

2. (Description of the Prior Art)

The non-contact type IC cards are not a recent development and are now coming into widespread use. One example of the prior art non-contact type IC card is schematically shown in FIG. **6** in sectional representation.

The prior art IC card shown in FIG. **6** is assembled by mounting a circuit module **3**, including various electronic component parts **2** and a power source cell **4** incorporated therein, on a generally rectangular first cover **10** made of thermoplastic resin, then mounting of an antenna coil **5** for selective transmission and receiving data by means of wireless signals to and from an external system appliance, applying a thermosetting bond **6** of, for example, an epoxy resin to a flat mating face of a peripheral wall which is parallel to a plane of a panel body of the first cover **10** and which is partially formed with a peripheral recess **13**, mounting a similarly shaped second cover **20**, made of a similar thermoplastic resin, onto the first cover **10** with a peripheral protuberance **23** received within the peripheral recess **13**, and finally heating the assembly to cure the thermosetting bond **6** to thereby complete the IC card.

The prior art IC card so assembled is susceptible to trouble. One of the troubles has been found resulting from separation between the first and second covers **10** and **20**, that is, an insufficient adhesive between the first and second covers **10** and **20**.

In order to achieve a sufficient robust bond between the first and second covers **10** and **20**, a very popular attempt is to increase the mating bond areas of the first and second covers **10** and **20**. It has, however, been found that since increase of the bond areas results in increase of the size of the IC card, increase of the bond areas is limited for the IC card which requires a compact size and a light-weight feature.

The inventors of the present invention have examined the bond strength between the first and second covers and, as a result thereof, have found that, for a given area of surface of contact between the first and second covers **10** and **20**, the bond strength measured in a direction parallel to, that is, in a shearing direction of, the bond areas of the first and second covers **10** and **20** is ten or more times that measured in a direction perpendicular to any one of the bond areas of the first and second covers **10** and **20**.

Also, in the manufacture of the prior art IC card, it has often been found that during the adhesive between the first and second covers, a deposit of the adhesive tends to run outwardly to eventually form bond flashes. Once the bond flashes are formed along a joint between the first and second covers, an extra process step of removing the bond flashes is required during the manufacture of the IC card.

SUMMARY OF THE INVENTION

The present invention is based on the above described finding and is intended to provide an improved non-contact IC card in which the first and second covers are sufficiently

bonded together to exhibit an increased bond strength with no need to increase the mating bond areas of the first and second covers.

Another important object of the present invention is to provide an improved non-contact IC card of the type referred to above wherein no extra step of removing the bond flashes such as required in the prior art is required.

To accomplish these objects, the present invention provides an IC card which comprises a first cover including a first flat panel portion and a first upright wall portion formed therein adjacent a perimeter of the flat panel portion, and a second cover including a second flat panel portion and a second upright wall portion formed therein adjacent a perimeter of the flat panel portion. The first upright wall defines a chamber for storing IC parts in cooperation with a portion of the first flat panel. The first and second covers are mated together with the first and second upright walls having a joint face bonded together in a butt fashion such as a cap-and-cup fashion or an inclined butt fashion.

The cap-and-cup joint so formed utilizes a peripheral surface of the first upright wall to form a plane of joint with a mating peripheral surface of the second upright wall that lies at an angle relative to any one of the first and second flat panels. Similarly, the inclined butt joint so formed utilizes an inclined free end face of the first upright wall remote from the first flat panel to form a plane of joint with a corresponding inclined free end face of the second upright wall remote from the second flat panel that lies at an angle relative to any one of the first and second flat panels. In either case, the plane of joint angled relative to any one of the first and second flat panels allows a bond component acting in the shearing direction relative to the plane of joint to be used as a bond strength with which the first and second covers are bonded together. Accordingly, without the mating adhesive surface areas being increased, the bond strength of the IC card can be increased.

Preferably, each of the first and second covers may also includes a peripheral wall formed therein along the perimeter of the associated cover so as to extend generally transverse to the associated flat panel. By so doing, the respective peripheral walls of the first and second covers can, when the first and second covers are mated together, define a reservoir inside the IC card for accommodating a portion of the adhesive material squeezing from a plane of joint between the first and second upright walls. This is particularly advantageous in that since that portion of the adhesive material is accommodated within the reservoir invisible from the outside of the IC card, such a step of removing flashes of the adhesive material hitherto required in the prior art IC card can be dispensed with.

According to the present invention, the adhesive material filled in the chamber flows outwardly from the chamber over the first upright wall and is in turn supplied to the plane of joint between the first and second upright walls to thereby form a bond layer. Therefore, portion of the adhesive material squeezing from the surface areas to be bonded together can be accommodated within the reservoir without being flowing outwardly from the IC card and, therefore, no extra step of applying the adhesive is also needed, making it possible to simplify the process of making the IC card.

It may be possible that when an external stress may act on the IC card from the second cover, the circuit module accommodated within the IC card may be damaged. To avoid this possibility, the IC card may include an elastic cushioning element interposed between the adhesive layer, formed by curing the adhesive material filled in the chamber,

and a portion of the second flat panel immediately above the adhesive layer so that the external stress applied to the IC card can be lessened to thereby protect the circuit module.

Instead of the use of the elastic cushioning element, a cushioning air layer may be employed. This air layer can readily be formed by designing the first upright wall to have a free end terminating at a position spaced a distance inwardly from the second flat panel to allow the cushioning air layer to be formed between the second flat panel and the bond layer in the chamber when the first and second covers are mated together.

The present invention also provides a method of making an IC card of the type comprising a first cover including a first flat panel and a first upright wall formed therein adjacent a perimeter of the flat panel so as to extend transverse to the flat panel and having a joint surface area, the first upright wall defining a chamber in cooperation with a portion of the first flat panel; and a second cover including a second flat panel and a second upright wall formed therein adjacent a perimeter of the flat panel so as to extend transverse to the flat panel and having a joint surface area. According to this method, a circuit module is first disposed within the chamber in the first cover, followed by filling an adhesive material within the chamber in a quantity sufficient to allow a top surface of the filled adhesive material to raise slightly above a plane flush with a free end face of the first upright wall. Then, the second cover is mounted on the first cover with the first upright wall encompassing the second upright wall, and the both are subsequently pressed together to allow a portion of the adhesive material within the chamber to squeeze outwardly from the chamber into a gap between the first and second upright walls so as to bond the first and second upright walls together.

With the IC card making method of the present invention, filling of the adhesive material within the chamber defined in the first cover and subsequent capping of the second cover over the first cover allows the adhesive material to be supplied to surface areas to be bonded together, no extra step of applying the adhesive material to the surface areas to be bonded together is needed, and therefore, no extra step of applying the adhesive material to the joint surface area is needed, making it possible to simplify the process of making the IC card.

Preferably, each of the first and second covers also includes a peripheral wall formed therein along the perimeter of the associated cover so as to extend generally transverse to the associated flat panel, such that the respective peripheral walls of the first and second covers, when the first and second covers are mated together, define a reservoir inside the IC card for accommodating portion of the adhesive material squeezing from a plane of joint between the first and second upright walls. In such case, when the first and second covers are mated together, that portion of the adhesive material can advantageously flow into the reservoir.

Because of this, no extra step of removing possible flashes is also needed, making it possible to simplify the process of making the IC card.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features of the present invention will become clear from the following description taken in conjunction with a preferred embodiment thereof with reference to the accompanying drawings, in which like parts are designated by like reference numerals and in which:

FIG. **1** is a schematic perspective view of a non-contact IC card embodying the present invention;

FIGS. **2**A to **2**F illustrates the sequence of assemblage of the IC card embodying the present invention, wherein FIGS. **2**C to **2**D are taken along the line II—II in FIG. **1**;

FIG. **3** is a schematic sectional view of a modified form of the IC card embodying the present invention;

FIG. **4** is a view similar to FIG. **3**, showing another modification of the IC card according to the present invention;

FIG. **5** is a fragmentary cross-sectional view taken along the line V—V in FIG. **1**; and

FIG. **6** is a view similar to FIG. **3**, showing the prior art non-contact IC card.

DETAILED DESCRIPTION OF THE EMBODIMENT

Referring first to FIGS. **1** and **2**F, a non-contact IC card comprises, as is the case with the prior art IC card shown in and described with reference to FIG. **6**, generally rectangular first and second covers **10** and **20** made of thermoplastic resin and having a substantially equal size. The first and second covers **10** and **20** are so configured and so designed that, when mated and boded together, they define a generally flattened closed box. Each of the first and second covers **10** and **20** comprises a flat panel **10***a* or **20***a* and a generally rectangular peripheral wall **10***b* or **20***b* formed integrally with the flat panel **10***a* or **20***a* so as to protrude from a perimeter of the flat panel **10***a* or **20***b* in a direction generally transverse thereto.

The flat panel **10***a* of the first cover **10** is formed integrally with a generally rectangular-sectioned tubular wall **11** which is positioned inside the peripheral wall **10***b* and which protrudes in a direction conforming to the direction of protrusion of the peripheral wall **10***b*, i.e., upwardly as viewed in FIG. **2**F, and perpendicular to the flat panel **10***a*. Similarly, the flat panel **20***a* of the second cover **20** is formed integrally with a generally rectangular-sectioned tubular wall **21** which is positioned inside the peripheral wall **20***b* and which protrudes in a direction conforming to the direction of protrusion of the peripheral wall **20***b*, i.e., downwardly as viewed in FIG. **2**F, and perpendicular to the flat panel **20***a*.

As will become clear from the subsequent description, one of the tubular walls **11** and **21** is so undersized relative to the other of the tubular walls **11** and **21** so that one tubular wall can be capped onto the other tubular wall so as to enclose the latter. In the illustrated embodiment, the tubular wall **11** is undersized relative to the tubular wall **21** and, accordingly, when the first and second covers **10** and **21** are mated together to complete the IC card, the tubular wall **21** receives therein and encompasses the tubular wall **11**.

The IC card of the above described construction is assembled in the manner which will now be described with reference to FIGS. **2**A to **2**F. FIG. **2**A illustrates a step of mounting electronic component parts **2** such as ICs (integrated circuits) and chip capacitors on a mother board to form a plurality of, for example, four, independent circuit modules **3** for the corresponding number of the IC cards.

The mother board shown in FIG. **2**A is subsequently broken, or divided in any suitable manner, into the four circuit modules **3** as shown in FIG. **2**B. The use of the mother board makes it possible to reduce the tact time required in accomplishing mounting of the IC components.

As shown in FIG. **2**C, one of the four circuit modules **3** is then mounted in a chamber **15** defined in the first cover **10**

by the tubular wall **11** in cooperation with the flat panel **10***a*. After the mounting of the circuit module **3**, and as shown in FIG. 2D, a power source cell **4** is mounted inside the chamber **15** and soldered to associated terminals on the circuit module **3**, followed by mounting and soldering of an antenna coil **5** for selective transmission and receiving of data to and from an external system appliance. The antenna coil **5** is, according to the present invention, accommodated within a peripheral space **16** defined between the tubular wall **11** and the peripheral wall **10***b*. As will become clear from the subsequent description, the peripheral space **16** concurrently serves as a sealed reservoir for a deposit of adhesive material.

Thereafter, as shown in FIG. 2E, a adhesive material **6** of thermosetting resin, for example, epoxy resin, is filled in the chamber **15** by the use of any suitable dispenser. The amount of the adhesive material **6** to be filled in the chamber **15** is preferably so chosen that, when the adhesive material **6** is completely filled in the chamber **15**, the top surface of the filled adhesive material **6** can raise slightly above a plane flush with a free end face of the tubular wall **11** opposite to the flat panel **10***b* as clearly depicted in FIG. 2E, it being however to be noted that the amount of portion of the adhesive material that raises above the plane flush with the free end face of the tubular wall **11** should be smaller then the volume of the free space or reservoir **16**.

Finally, as shown in FIG. 2F, the second cover **20** is mounted on the first cover **10** with the tubular wall **21** receiving therein the tubular wall **11** integral of the first cover **10**. Thereafter, the assembly including the first and second covers **10** and **20** is placed in a constant temperature bath maintained at, for example, 70° C. to cause the adhesive material **6** to cure, thereby completing the IC card.

The tubular wall **11** of the first cover **10** is so sized relative to the tubular wall **21** of the second cover **20** that an annular gap of about 0.1 mm can be formed between an inner peripheral surface of the tubular wall **21** and an outer peripheral surface of the tubular wall **11**. Accordingly, when the second cover **20** is mounted on the first cover **10** and is then pushed against the first cover **10** or the both are pressed together, that portion of the adhesive material **6** raising above the plane flash with the free end face of the tubular wall **11** is forced to flow into the annular gap between the mutually confronting outer and inner peripheral surfaces of the tubular walls **11** and **21** until it reaches a portion of the reservoir **16** adjacent a free end face of the tubular wall **21** positioned outside the tubular wall **11** of the first cover **10**. Placement of the assembly within the constant temperature bath results in curing of not only a major portion of the adhesive material **6** filled within the chamber **15**, but also that portion of the adhesive material **6** which has flowed into the annular gap between the mutually confronting outer and inner peripheral surfaces of the tubular walls **11** and **21**.

Thus, according to the present invention, the adhesive material **6** used serves not only to bond the respective flat panels **10***a* and **20***a* of the first and second covers **10** and **20** together, but also to bond the mutually confronting outer and inner peripheral surfaces of the tubular walls **11** and **21** together. Since the mutually confronting outer and inner peripheral surfaces lie in a direction conforming to the direction along which the first and second covers **10** and **20** are separated and perpendicular to any one of the respective flat panels **10***a* and **20***a*, the IC card embodying the present invention can exhibit a bond strength which is ten or more times that exhibited by the IC card wherein surfaces to be joined together by the use of a adhesive material lie substantially parallel to any one of the flat panels, even though the area of each of the surfaces to be joined remains the same. Accordingly, with the IC card embodying the present invention, the possibility of separation of one of the covers from the other of the covers, which would result in a malfunctioning of the IC card, can advantageously be minimized.

Moreover, that portion of the adhesive material **6** which has reached and cured at the portion of the reservoir **16** adjacent the free end face of the tubular wall **21** is located inside the reservoir **16** and is invisible from the outside of the IC card. Thus, according to the present invention, no extra step of removing flashes of the adhesive material which are, according to the prior art IC card shown in FIG. **6**, apt to be formed around the outer perimeter of the IC card, is needed during the manufacture of the IC card of the present invention. This makes it possible to simplify the manufacture of the IC card.

It is to be noted that respective free end faces of the peripheral walls **10***b* and **20***b* of the first and second covers **10** and **20**, which are held in contact with each other when the second cover **20** is mounted onto the first cover **10** in the manner described above may or may not be bonded with each other, although in the illustrated embodiment they are not bonded together. Where the respective free end faces of the peripheral walls **10***b* and **20***b* are not bonded together such as shown, that portion of the adhesive material **6** which has flowed into the annular gap between the mutually confronting outer and inner peripheral surfaces of the tubular walls **11** and **21** is preferably accommodated within the reservoir **16** at a location adjacent the free end face of the tubular wall **21**. For this reason, in consideration of the accuracy of filling of the adhesive material **6** into the chamber **15**, the volume of a portion of the reservoir **16** below the level flush with the free end face of the peripheral wall **10***b* is preferably so chosen as to be about 30% of the volume of the chamber **15**.

In the foregoing embodiment of the present invention, the adhesive material **6** has been shown and described as filled in the chamber **15**. This is particularly advantageous in that both of the circuit module **3** and the electronic component parts **2** on the circuit module **3** can be firmly retained in position.

However, the present invention does not necessarily preclude the possibility of only the free end faces of the tubular walls **11** and **21** being bonded to the flat panels **20***a* and **10***a*, respectively.

In addition, in the illustrated embodiment, the tubular walls **11** and **12** have been shown and described as bonded in side-by-side fashion. In other words, each of the tubular walls **11** and **21** has such a length that when the first and second covers **10** and **20** are mated together the free end face of the tubular wall **11** and the free end face of the tubular wall **21** can terminate respectively within the second and first covers **20** and **10** to accomplish a so-called cap-and-cup joint. However, in the assembled condition of the IC card according to the present invention, the tubular walls **11** and **21** may be aligned in position with each other and, in such case, the extent to which each of the tubular walls **11** and **21** protrudes from the associated flat panel **10***a* or **20***a* towards the opposite flat panel **20***a* or **10***a* should be so chosen as to form an inclined butt joint. The inclined butt joint refers to a joint in which the plane of the joint between the tubular walls **11** and **21** in the assembled condition of the IC card extend slantwise relative to the direction of protrusion of the tubular walls **11** and **21** from the associated flat panel **10***a* and **20***a*.

Referring now to FIG. **3** showing a modified form of the IC card according to the present invention, a generally rectangular elastic sheet **31** such as, for example, a silicone rubber sheet, is interposed between the flat panel **20***a* of the second cover **20** and the cured adhesive material **6** within the chamber **15**. The interposition of the elastic sheet **31** serves as a cushioning element effective to protect the circuit module **3** from being damaged by the effect of external impacts or shocks.

In another modified form of the IC card shown in FIG. **4**, an air layer **32** is formed between the flat panel **20***a* of the second cover **20** and the cured adhesive material **6** within the chamber **15**. This air layer **32** can readily be formed by choosing the extent of protrusion of the tubular wall **11** to such a value that, when the first and second covers **10** and **20** are mated together, the free end face of the tubular wall **11** may terminate at a position spaced a distance inwardly from the flat panel **20***a* of the second cover **20**.

The air layer **32** shown in FIG. **4** serves the same purpose as that accomplished by the use of the elastic sheet **31** shown in FIG. **31**.

FIG. **5** illustrates a cross-section, taken along the line V—V in FIG. **1**, of one corner area of the IC card where a chain hole **30** is formed. This chain hole **30** is used for attachment of the IC card to a key holder by means of a connecting element such as, for example, a chain, thread or ring. As shown in FIG. **5**, one corner area of the first cover **10** is formed with an annular recess **12** extending inwardly of the first cover **10** and, on the other hand, a corresponding corner area of the second cover **20** is formed with a annular projection **22** of a size sufficient to be press-fitted into the round recess **12**. Thus, it will readily be understood that when the first and second covers **10** and **20** are mated together in the manner described hereinbefore, respective hollows in the annular recess and projection **12** and **22** are coaxially aligned with each other to define the chain hole **30**.

The use of the annular projection **22** in the second cover **20** that is adapted to be press-fitted into the annular recess **12** in the first cover **10** is, regardless of the presence or absence of the chain hole **30**, particularly advantageous in that any possible separation of the second cover **20** from the first cover **10** which would otherwise take place before the filled adhesive material **6** is completely cured can be eliminated.

From the foregoing description, it has now become clear that the first and second covers are mated together with the respective tubular walls bonded together in either a cap-and-cup fashion or an inclined butt fashion and, accordingly, a bond component acting in the shearing direction relative to the plane of joint enhances the bond strength of the plane of joint. Accordingly, as compared with the case in which the plane of joint does not incline such as in the prior art IC card, for a given adhesive area, the bond strength can be increased. In particular, if the plane of joint lies perpendicular to any one of the respective flat panels of the first and second covers, the bond strength can attain a value about ten times that exhibited by the prior art IC card, making it possible to minimize the possible occurrence of trouble in the IC card.

It is also clear that since according to the present invention filling of the adhesive material within the chamber defined in the first cover and subsequent capping of the second cover over the first cover allows the adhesive material to be supplied to surface areas to be bonded together, no extra step of applying a adhesive material to the surface areas to be bonded together is needed. Moreover, portion of the adhesive material squeezing from the surface areas to be bonded together can be accommodated within the reservoir without being flowing outwardly from the IC card and, therefore, no extra step of removing possible flashes is also needed, making it possible to simplify the process of making the IC card.

Although the present invention has been described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims, unless they depart therefrom.

What is claimed is:

1. An IC card which comprises:

a first cover including a first flat panel portion and a first upright wall portion formed adjacent a perimeter of the flat panel portion, said first upright wall defining a chamber for storing IC parts in cooperation with said first panel portion;

a second cover including a second flat panel portion and a second upright wall portion formed adjacent a perimeter of the flat panel; and

said first and second covers being mated together with the first and second upright walls respectively having a first joint face and a second joint face thereof bonded together in a butt fashions,

wherein each of the first and second covers further include respectively each peripheral upright walls formed therein along the outer perimeter of the associated cover so as to define a reservoir inside accommodating a portion of an adhesive material squeezing through a clearance between the first and second upright walls from the chamber for storing the IC parts when said first and second covers are mated together.

2. The IC card as claimed in claim **1**, wherein a portion of the adhesive material to be filled in the chamber forms a contacting adhesive layer between the first and second upright walls for bonding the first and second covers.

3. The IC card as claimed in claim **2**, further comprising a wide spread elastic cushioning element interposed between the adhesive layer filled in the chamber and an inner face of the second flat panel.

4. The IC card as claimed in claim **2**, wherein the first upright wall has a free end terminating at a position spaced a distance inwardly from the inner face of the second flat panel to allow a cushioning air layer to be formed between the second flat panel and the adhesive layer in the chamber when the first and second covers are mated together.

5. The IC card of a non-contact type as claimed in claim **1**, which has no interfacing terminal electrode exposed to the outside, but utilizes wireless signals for communication with external system appliances.

6. A method of making an IC card comprising a first cover including a first flat panel portion and a first upright wall portion formed therein adjacent a perimeter of the flat panel portion, said first upright wall portion defining a chamber in cooperation with a portion of the first flat panel portion; and a second cover including a second flat panel portion and a second upright wall portion formed therein adjacent a perimeter of the flat panel portion; each of said first and second upright wall portions respectively having a joint face; each of the first and second covers further including a peripheral wall formed therein along the outer perimeter of the associated cover so as to extend generally transverse to the associated flat panel, such that the respective peripheral

walls of the first and second covers, when said first and second covers are mated together, define a reservoir inside the IC card accommodating portion of an adhesive material squeezing from a plane of Joint between the first and second upright walls, said method comprising the steps of:

disposing a circuit module within the chamber in the first cover;

filling an adhesive material within the chamber in a quantity sufficient to allow a top surface of the filled adhesive material to raise slightly above a plane flush with a free end face of the first upright wall portion;

mounting the second cover on the first cover with the first upright wall portion encompassing the second upright wall portion; and

pressing the first and second covers together to allow a portion of the adhesive material within the chamber to squeeze outwardly from the chamber into a clearance between the first and second upright walls, thereby allowing that portion of the adhesive material to flow into the reservoir so as to joint the first and second upright walls together.

* * * * *

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United States Patent [19]

Mundigl et al.

[11] Patent Number: 5,809,633

[45] Date of Patent: Sep. 22, 1998

[54] **METHOD FOR PRODUCING A SMART CARD MODULE FOR CONTACTLESS SMART CARDS**

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[73] Assignee: **Siemens Aktiengesellschaft**, Munich, Germany

[21] Appl. No.: **812,111**

[22] Filed: **Mar. 5, 1997**

Related U.S. Application Data

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[6] **H02P 11/00**

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[58] **Field of Search** 29/600, 827; 235/382, 235/380

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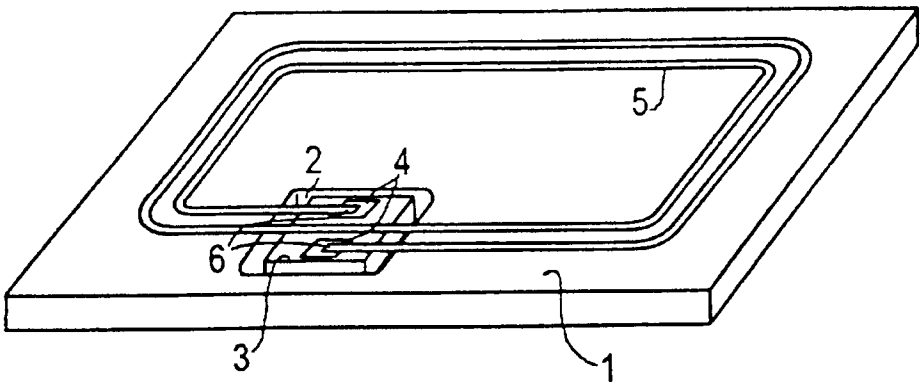
Primary Examiner—Carl J. Arbes

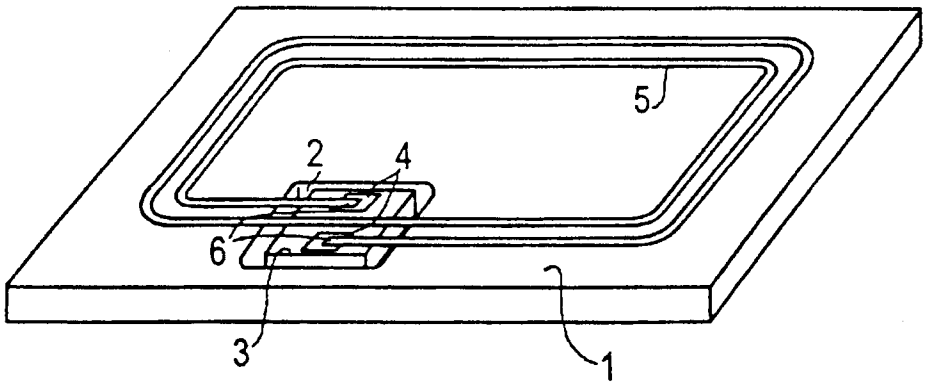
Attorney, Agent, or Firm—Herbert L. Lerner; Laurence A. Greenberg

[57] **ABSTRACT**

A method for producing a smart card module includes bonding one end of a thin wire onto a first contact zone of a semiconductor chip. The wire is guided in a plurality of turns forming an antenna coil. The wire is bonded onto a second contact area of the semiconductor chip. The wire turns of the antenna coil and the semiconductor chip are placed on a carrier body.

3 Claims, 1 Drawing Sheet

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METHOD FOR PRODUCING A SMART CARD MODULE FOR CONTACTLESS SMART CARDS

CROSS-REFERENCE TO RELATED APPLICATION

This application is a Continuation of International Application Serial No. PCT/DE95/01201, filed Sep. 5, 1995 published as WO96/07984, Mar. 14, 1996.

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to a method for producing a smart card module.

In the case of contactless smart cards, the power required to operate the semiconductor chip contained in them is supplied through at least one antenna coil, and transformer transmission generally is selected. The data transfer also takes place through that coil.

In that case, not only printed or etched coils or coils grown by electrodeposition in the form of striplines but also wound enamel-insulated wire coils are customary, and copper is used as the basic material for such enamel-insulated wire coils.

In order to connect the coil to the semiconductor chip, the insulation is initially stripped from the connections of the coil, for example through the use of heating, brushing, chemical treatment or tin-coating and then a contact is produced, for example through the use of laser soldering, gap welding, ultrasonic welding, wire-wrap or adhesive bonding with silver enamel adhesive. Therefore, the production of such a connection in each case requires a multiplicity of different work operations and assembly steps, which also require a plurality of machines for their implementation.

German Patent DE 37 21 822 C1 discloses connecting an antenna coil to a semiconductor chip through bonds. Therefore, in the case of that disclosure, a coil must initially be wound and the ends of the coil are then connected to the semiconductor chip through bonds in a further work step.

SUMMARY OF THE INVENTION

It is accordingly an object of the invention to provide a method for producing a smart card module for contactless smart cards, which overcomes the hereinafore-mentioned disadvantages of the heretofore-known devices of this general type and which is simple, cost-effective and can be easily automated.

With the foregoing and other objects in view there is provided, in accordance with the invention, a method for producing a smart card module, which comprises bonding one end of a thin wire onto a first contact zone of a semiconductor chip; guiding the wire, such as with a bonding head, in a plurality of turns forming an antenna coil; bonding the wire onto a second contact area of the semiconductor chip; and placing the wire turns of the antenna coil and the semiconductor chip on a carrier body.

The coil connections are bonded, in an inventive manner, directly onto contact zones of the semiconductor chip. In this case, the bonding device is integrated directly into the wire guiding head of the automatic coil-winding machine, with the result that all of the assembly steps can be carried out using one machine. An aluminum wire is used with particular advantage for the coil. This wire is more than half as light as copper and also has a modulus of elasticity which is only approximately half as large, with the result that the finished card has a lower rigidity. This type of thick-wire bonding is known, for example, in power electronics and is controlled well, with the result that a high yield is achieved.

In accordance with another feature of the invention, the semiconductor chip is disposed in such a manner as to be suspended freely and held only by the bond contacts in a recess in the carrier body, with the result that it is well protected against breakage in the event that the smart card is subjected to bending stress.

Other features which are considered as characteristic for the invention are set forth in the appended claims.

Although the invention is illustrated and described herein as embodied in a method for producing a smart card module for contactless smart cards, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

The construction and method of operation of the invention, however, together with additional objects and advantages thereof will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

The FIGURE of the drawing is a diagrammatic, perspective view of a possible exemplary embodiment of a smart card module according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now in detail to the single FIGURE of the drawing, there is seen a flat carrier body **1** which is made of flexible, non-conductive material and has a recess **2**. A semiconductor chip **3** is inserted into the recess. The semiconductor chip **3** has two contact zones **4** which are enlarged in comparison with the customary chip contact zones through the use of a gold plating, for example. Connections **6** of an antenna coil **5** are secured on the contact zones **4** through the use of bond contacts. The antenna coil **5** is a wire which is advantageously made of aluminum. In this case, the wire has initially been bonded onto one of the contact zones **4**, then wound through the use of a guiding head of an automatic wire-winding machine, into which a bonding device is integrated, in a plurality of turns to form the coil (only two turns are illustrated in the FIGURE, but there may also be more) and finally bonded again onto the other contact zone. The semiconductor chip **3** with the coil **5** which is secured thereto in an inventive manner is subsequently inserted into the recess **2** in the carrier body **1**, with the result that the coil **5** is disposed on the carrier body **1**. In this case, the carrier body **1** can have the length and width of a finished smart card, with the result that the smart card can be completed merely through the use of corresponding coverings on the carrier body. However, the carrier body **1** may also have smaller dimensions than a smart card, with the result that it can be inserted as an inlet or insert into a center section of the smart card which is in the form of a frame.

We claim:

1. A method for producing a smart card module, which comprises:

bonding one end of a thin wire onto a first contact zone of a semiconductor chip;

guiding the wire in a plurality of turns forming an antenna coil;

bonding the wire onto a second contact area of the semiconductor chip; and

placing the wire turns of the antenna coil and the semiconductor chip on a carrier body.

2. The method according to claim **1**, which comprises performing the guiding step with a bonding head.

3. The method according to claim **1**, which comprises placing the semiconductor chip in a recess in the carrier body and suspending the semiconductor chip from bonds at the ends of the wire, while carrying out the step of placing the wire turns of the antenna coil and the semiconductor chip on the carrier body.

* * * * *

US005817207A

United States Patent [19]

Leighton

[11] Patent Number: 5,817,207

[45] Date of Patent: Oct. 6, 1998

[54] **RADIO FREQUENCY IDENTIFICATION CARD AND HOT LAMINATION PROCESS FOR THE MANUFACTURE OF RADIO FREQUENCY IDENTIFICATION CARDS**

[76] Inventor: **Keith R. Leighton**, 2817 Fulmer Rd., Lorain, Ohio 44053

[21] Appl. No.: **727,789**

[22] Filed: **Oct. 7, 1996**

Related U.S. Application Data

[60] Provisional application No. 60/005,685 Oct. 17, 1995.

[51] **Int. Cl.**[6] **B32B 31/20**

[52] **U.S. Cl.** **156/298**; 156/312

[58] **Field of Search** 156/300, 312, 156/311, 298

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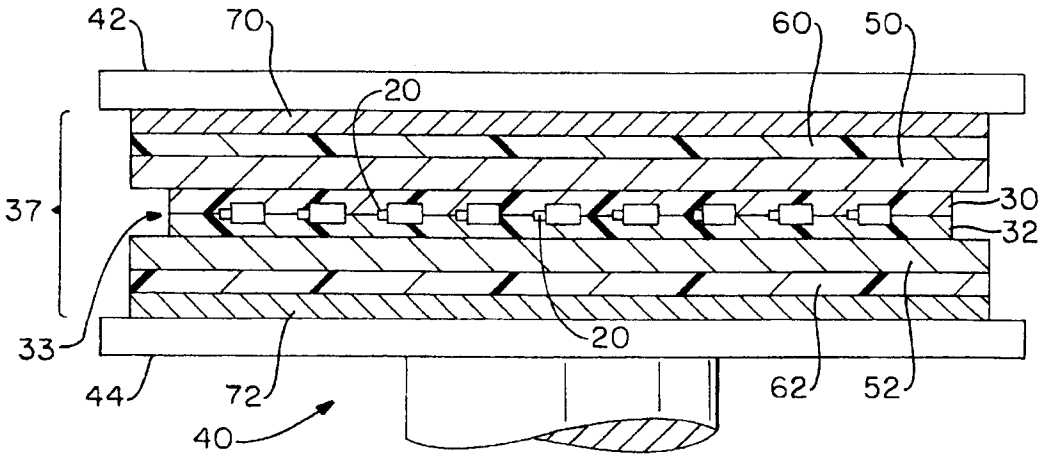
Primary Examiner—Francis J. Lorin

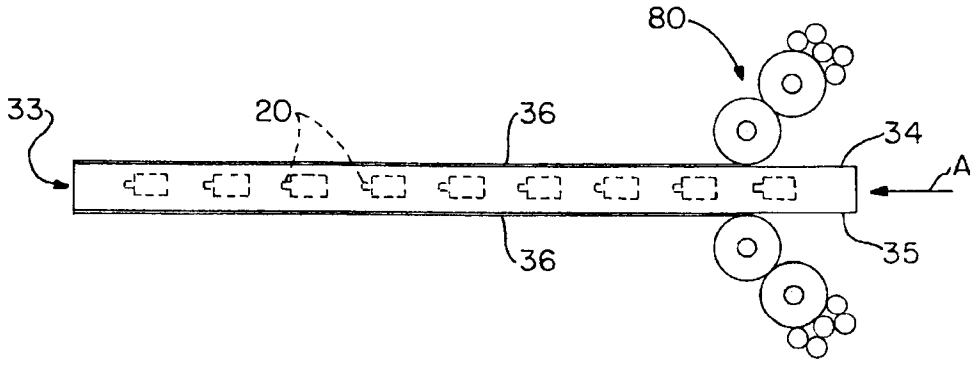
Attorney, Agent, or Firm—Oldham & Oldham Co., L.P.A.

[57] **ABSTRACT**

A plastic card, such as a radio frequency identification card, including at least one electronic element embedded therein and a hot lamination process for the manufacture of radio frequency identification cards and other plastic cards including a micro-chip embedded therein. The process results in a card having an overall thickness in the range of 0.028 inches to 0.032 inches with a surface suitable for receiving dye sublimation printing—the variation in card thickness across the surface is less than 0.0005 inches. A card manufactured in accordance with the present invention also complies with all industry standards and specifications. Also, the hot lamination process of the present invention results in an aesthetically pleasing card. The invention also relates to a plastic card formed in accordance with the hot lamination process of the present invention.

17 Claims, 3 Drawing Sheets





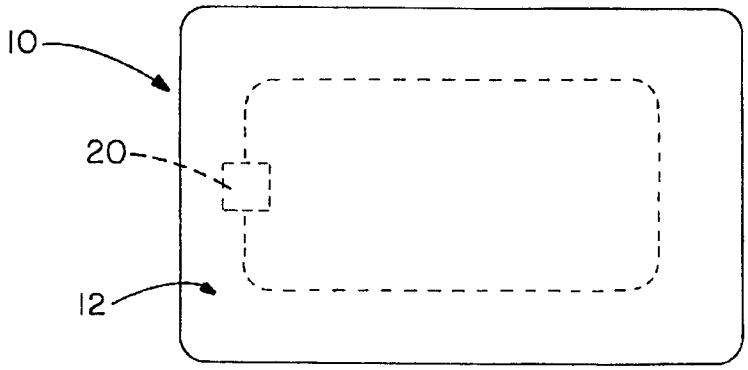


FIG.-1

FIG.-2

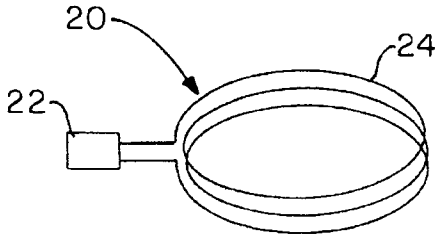


FIG.-3A

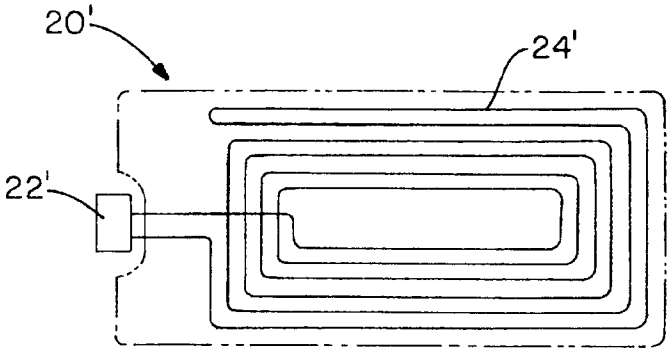


FIG.-3B

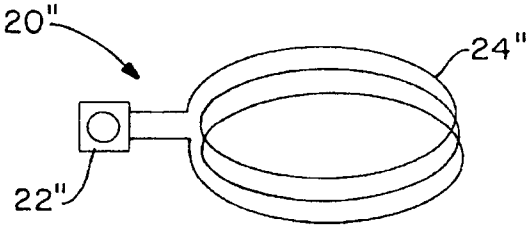


FIG.-3C

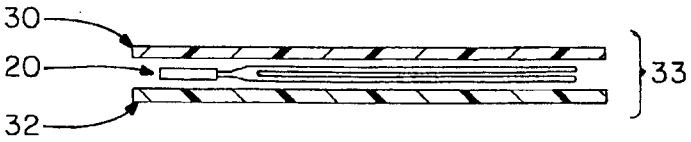


FIG.-4

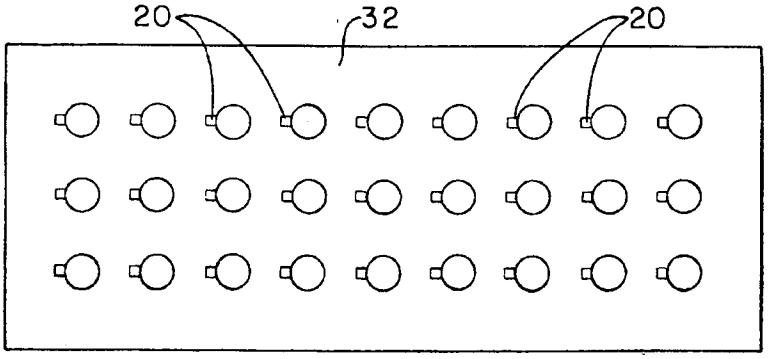


FIG.-5

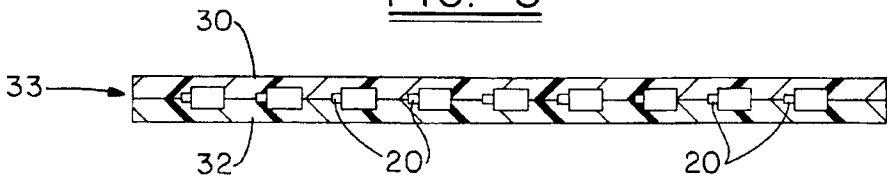


FIG.-6

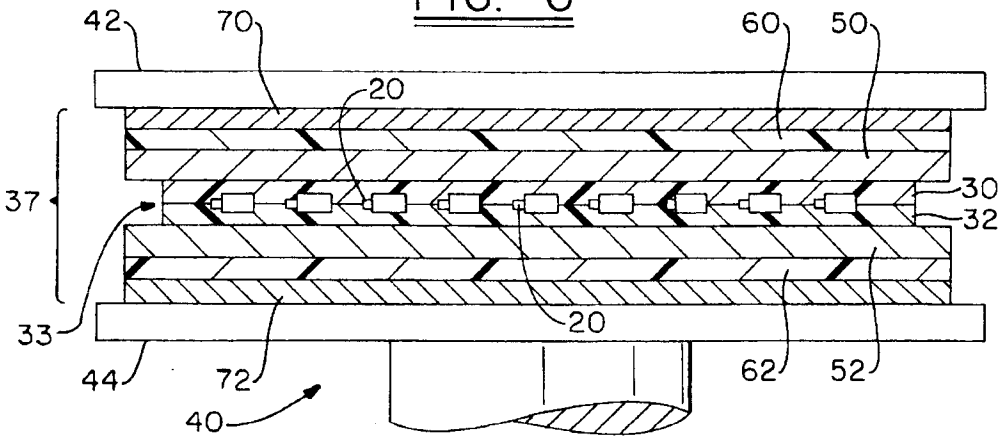


FIG.-7

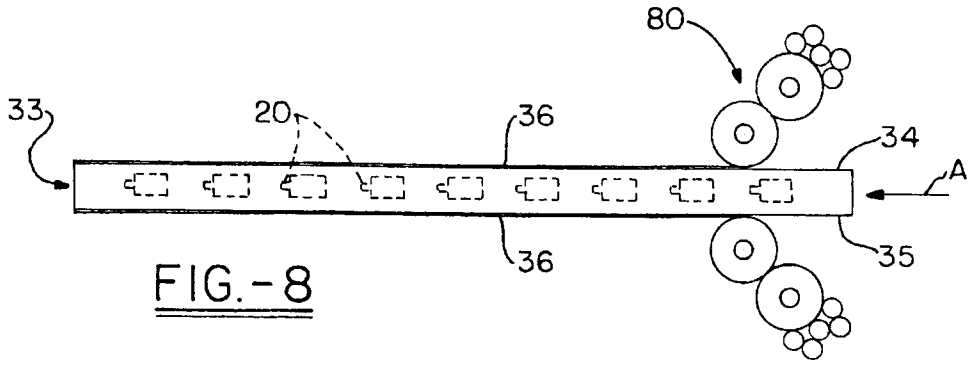


FIG.-8

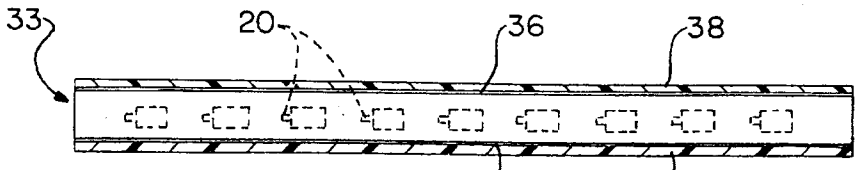


FIG.-9

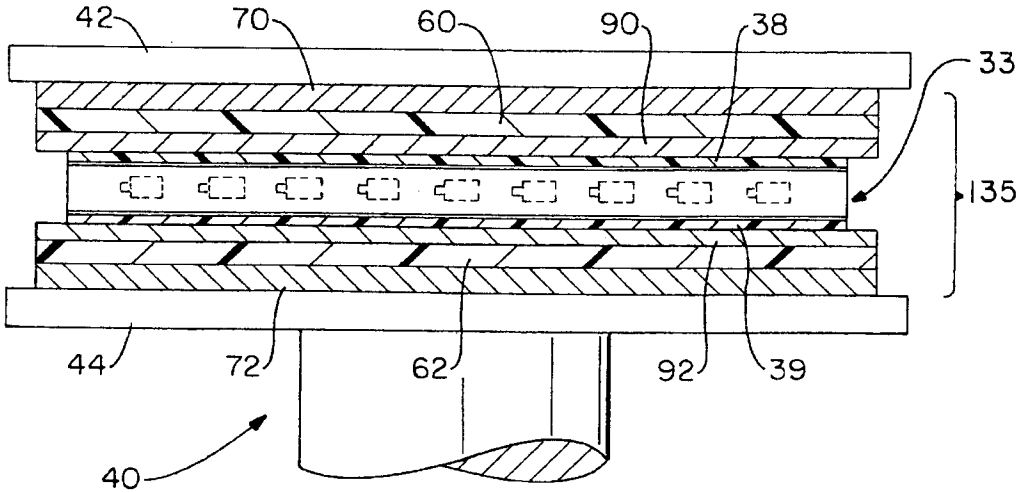


FIG.-10

RADIO FREQUENCY IDENTIFICATION CARD AND HOT LAMINATION PROCESS FOR THE MANUFACTURE OF RADIO FREQUENCY IDENTIFICATION CARDS

This application claims the benefit of the following: U.S. Provisional Application No.: 60/005,685, filing date Oct. 17, 1995.

FIELD OF THE INVENTION

The present invention relates generally to plastic cards and the manufacture thereof, and more particularly to radio frequency identification (RFID) cards and the manufacture of RFID cards that conform to industry size and performance standards and conventions and that have a superior outer surface to known RFID cards such that card may receive dye sublimation printing or the like.

BACKGROUND OF THE INVENTION

As the use of plastic cards for credit cards, automated teller machine (ATM) cards, identification cards, and like continues to become more widespread, the problems associated with the use of such cards correspondingly increase. Credit card fraud and identification card fraud are becoming larger problems everyday, and this fraud has introduced uncertainties into our systems of commerce and our security systems. Using easily available technology, criminals are able to manufacture credit/debit cards, ATM cards, identification cards, and the like having another's account code, identification code, or other personal information embedded in the magnetic stripe thereof. Thus, for example, criminals may steal hundreds or thousands of legitimate credit card account numbers and manufacture many additional cards bearing the stolen information. These fraudulent cards are then usable by the criminals to purchase goods and to receive cash with the legitimate card holder and the card issuer left holding the bill. Likewise, so called debit cards are becoming increasingly popular. These cards have stored thereon a certain amount of value for which the card owner has previously paid. For example, a subway rider may purchase a card good for 50 fares, with one fare being deducted from the card each time the owner rides the subway. Criminals have also been able to manipulate the data stored on these cards to defraud the merchants and others.

The ease in which criminals have been able to manufacture and or manipulate known cards results from the existence of the easily altered magnetic stripe storage medium used by known cards. These magnetic stripes are easily programmed and reprogrammed using commonly available technology. Thus, there has been found a need in the plastic card industry to provide a more secure plastic card that is very difficult or impossible to fraudulently manipulate. The most likely solution to the above-noted problems associated with known plastic cards is the RFID card and other cards including computer chips embedded therein rather than, or in addition to, a magnetic stripe. While these RFID cards and like have been found to be successful in preventing or limiting fraud, they are more difficult and expensive to manufacture relative to ordinary magnetic stripe cards. One of the biggest obstacles to the wide spread manufacture and use of RFID cards has been the inability of card manufacturers to manufacturer an RFID card that meets all industry standards and specifications, such as those set by the International Standards Organization (ISO), that are sufficiently aesthetically pleasing (wherein the embedded electronics are hidden from view), and that have a sufficiently regular or flat surface such that one or both surfaces of the card may be printed on using the very popular and widespread dye sublimation technology. Known plastic cards with computer chips and like embedded therein are too thick to work in connection with existing card reading machinery (ATM machines, telephones, and like) and have a surface that is too irregular to properly and consistently receive dye sublimation printing. Furthermore, prior attempts to manufacture a sufficiently thin plastic card including a computer chip embedded therein have resulted in a card with inferior aesthetic qualities such as the ability to see the embedded computer chip through the plastic.

SUMMARY OF THE INVENTION

The present invention is therefore directed to a plastic card having at least one electronic element embedded therein and to a hot lamination method for the manufacture of plastic cards including at least one electronic element therein. The card has an overall thickness in the range of 0.028 inches to 0.032 inches and comprises a plastic core having at least one electronic element embedded therein with at least one of the upper and lower surfaces of the core comprising a coating printed or otherwise applied thereon. An overlaminate film is preferably provided over the coated surface of the core and the resulting card has a variation in thickness across the surfaces thereof of no greater than approximately 0.0005 inches. The hot lamination method of the present invention comprises the steps of providing first and second plastic core sheets, positioning at least one electronic element between the first and second core sheets to thus form a core, and placing the core in a laminator and closing the laminator without applying laminator ram pressure to the core. A heat cycle is applied to the core sheets in the laminator thus liquefying or partially liquefying the sheets. The laminator ram pressure is then increased in combination with the heat. A cooling cycle is then applied to the core in the laminator, preferably with an associated increase in ram pressure, and the core is removed from the laminator. At least one surface of the core is then printed on using a printing press or similar printing apparatus, a sheet of overlaminate film is placed on at least one side of the core, and the core is then again placed in a laminator. A heat cycle is applied to the core with its overlaminate film, and a cooling cycle is thereafter applied, resulting in a sheet of plastic card stock from which one or more cards may be cut. The invention is also directed to a card manufactured in accordance with the above process which results in a plastic card having a thickness in the range of approximately 0.028 inches to 0.032 inches with a surface smoothness of at least approximately 0.0005 inches as is required by ISO and American National Standards Institute (ANSI) standards.

The present invention provides numerous advantages over known plastic cards and known plastic card manufacturing processes, including the formation of a plastic card with electronic elements such as a computer chip embedded therein with a pleasing aesthetic appearance, with a sufficiently smooth and regular surface such that the card may receive dye sublimation printing, and with sufficient durability and characteristics to comply with all industry specifications and standards.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top plan view of a plastic card in accordance with the present invention;

FIG. **2** is a side elevational view of the card shown in FIG. **1**;

FIGS. **3A–3C** are top plan views of various electronic elements that may be embedded in a card in accordance with the present invention;

FIG. **4** is an exploded, schematic view of an electronic element position between two plastic core sheets to form a core;

FIG. **5** is a top plan view of a plurality of electronic elements positioned on a sheet of plastic core stock such that they may be covered by a similar sheet of core stock;

FIG. **6** is a schematic cross-sectional view of one or more electronic elements positioned between sheets of plastic core stock;

FIG. **7** schematically illustrates a book comprising the core, as it is positioned in a laminator apparatus;

FIG. **8** schematically illustrates the core as it is being printed on after removal from the laminator using a printing press or similar printing apparatus;

FIG. **9** is a cross-sectional view schematically illustrating the application of an overlaminate film to at least one side of the core;

FIG. **10** schematically illustrates the core with overlaminate film, as it is placed in a laminator for final processing to form a sheet of card stock.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a plastic card including at least one electronic element embedded therein. The present invention also relates to a hot lamination process for the manufacture of plastic cards, and more particularly to a hot lamination process for the manufacturer of plastic cards that include an electronic element, such as a computer chip or other electronic element embedded therein. The electronic element may perform a wide variety of functions and take a wide variety of forms. Such cards, without regard to the particular electronic element embedded therein, will hereinafter be referred to as radio frequency identification (RFID) cards. The present invention also relates to a card formed in accordance with the invention.

Referring now to FIG. **1**, there can be seen a plastic RFID card **10** manufactured in accordance with the present invention and including an electronic element **20** embedded therein. Card **10** includes an upper surface **12** and a lower surface **14**. Electronic element **20** may take a wide variety of forms and perform a wide variety of functions. As shown in FIG. **3A–3C** respectively, electronic element **20**, **20'**, **20"** may be provided by a micro-chip **22** including a wire antenna **24** connected thereto, a micro-chip **22'** and a circuit board antenna **24'**, a read/write micro-chip **22"** and a wire coil antenna **24"**, or any other suitable electronic element. These electronic elements **20**, **20'**, **20"** and their insertion into plastic cards is not new, however, the present invention provides a new hot lamination process for manufacturing plastic cards **10** with these electronic elements **20**, **20'**, **20"** embedded therein such that the cards **10** are of a superior quality, such that the cards **10** meet all ISO and other industry specifications and standards, in such that at least one of the upper and lower surfaces **12**, **14** of card **10** is sufficiently smooth and is otherwise is capable of receiving dye sublimation printing. Specifically, a card in accordance with the present invention has a thickness of approximately in the range of 0.028 inches to 0.032 inches with a surface smoothness of 0.0005 inches.

As shown in FIGS. **4–10** one or more cards **10** in accordance with the present invention may be manufactured

by positioning an electronic element **20** between first and second sheets of card stock **30**, **32** to form a core **33**. Preferably is shown in FIG. **5–10**, a plurality of cards are manufactured simultaneously, in thus, a plurality of electronic elements **20** are positioned between the first and second sheets of plastic core stock **30**, **32** (only the second sheet **32** begin shown in FIG. **5** for clarity). When a plurality of electronic elements **20** are positioned between first and second sheets plastic core stock **30**, **32**, electronic elements **20** are properly positioned relative to one another such that a plurality cards may be cut from the resulting card stock. Plastic core sheets **30**, **32** may be provided by a wide variety of plastics, the preferred being polyvinyl chloride (PVC) having a thickness in the range of 0.007 inches to 0.024 inches and preferably having a thickness of approximately 0.0125 inches each. Those skilled in the art will recognize that the thickness of the plastic core sheets will depend upon the thickness of the one or more electronic elements that are to be embedded therebetween. Other suitable plastics that may be utilized include polyester, acrylonitrile-butadiene-styrene (ABS), and any other suitable plastic.

Subsequent to placing one or more electronic elements **20** between the first and second sheets **30**, **32** of plastic core stock to form a core **33**, this core **33** is placed in a laminator apparatus **40** of the type well known in the art of plastic card manufacturing. As is shown in FIG. **7**, laminator **40** includes upper and lower platens **42,44** for applying ram pressure to an article positioned therebetween. In addition to the ability to apply ram pressure, laminator **40** is preferably of the type having controlled platens **42,44** that may provide both heat and chill cycles and preferably includes cycle timer to regulate cycle time. Core **33** is positioned between first and second laminating plates **50**, **52**, one of which is preferably matte finished to provide laminated core **33** with at least one textured outer surface. First and second laminating pads **60**, **62** are positioned outside of the laminating plates **50**, **52**, and first and second steel plates **70**, **72** are likewise positioned outside of pads of **60**, **62** and the entire assembly forms a book **35** for being positioned in laminator **40** between platens **42**, **44**.

Once book **35** is positioned in laminator **40** as shown in FIG. **7**, the first lamination cycle is initiated by closing laminator platens **42**, **44**, preferably applying little or no ram pressure to book **35**. A laminator heat cycle is initiated, bringing the temperature of platens **42,44** up to a range of 275° F. to 400° F., and most preferably up to a range of 300° F. to 370° F. for a period of greater than 5 minutes, and preferably in the range of 7 to 10 minutes. Once the heat cycle has been applied to the book **35** as is set forth above, the ram pressure of laminator **40** is increased to facilitate the flow of the plastic core sheets **30**, **32** so that the one or more electronic elements **20** are encapsulated there by, and so that sheets **30**, **32** form a uniform core **33** (seen most clearly in FIGS. **8–10**) with upper and lower surfaces **34,35**. As mentioned, the use of matte finished laminator plates **50,52** provides surfaces **34,35** with a slightly roughened or textured quality which will facilitate the application of a coating thereto as is discussed below. The ram pressure applied during the heat cycle and the length of the heat cycle may vary, depending especially upon the size of sheets **30**, **32**. For example, the cycle time may be in the range of 10–15 minutes. In one example, a ram pressure of 940.135 pounds per square inch (p.s.i.) was applied for 10–15 minutes to form a uniform core **33**, using sheets **30,32** of a size in the range of 12 inches by 24 inches to 24 inches by 36 inches.

Subsequent to the above heat cycle, laminator **40** applies a chill cycle to book **35** during which time the ram pressure

of the laminator **40** is increased, preferably by approximately 25% until the platens **42,44** have cooled to approximately 40° F. to 65° F. for approximately 10–15 minutes. Core **33** may then be removed from laminator **40** for additional processing.

Subsequent to the removal of core **33** from laminator **40**, and as illustrated in FIG. **8**, core **33** is coated on at least one of it's upper and lower surfaces **34**, **35** with a layer of printing ink **36**. This may be accomplished using a wide variety of printing techniques such as offset printing, letterpress printing, screen printing, roller coating, spray printing, litho-printing, and other suitable printing techniques. As shown in FIG. **8**, core **33** is fed in the direction indicated with arrow A through a printing press, a lithographic printer, or a similar apparatus **80**. This printing step is performed to coat at least one surface **34**, **35** of core **33** with a layer of aesthetically pleasing ink **36**. This layer of ink **36** cosmetically hides the one or more electronic elements **20** that are embedded within core **33**, and prevents these one or more electronic elements **20** from showing through the relatively thin core **33**. In this manner, the one or more electronic elements **20** encapsulated in core **33** are completely hidden from view without requiring the plastic used in the manufacture core **33** to be excessively thick.

Referring now to FIGS. **9–10**, the final processing of core **33**, which now comprises a layer of ink **36** or the like on at least one surface **34,35** thereof, is schematically illustrated. A layer of overlaminate film such as clear overlaminate film **38,39** is positioned on at least one ink coated surface **34,35** of core **33**, and preferably core **33** is positioned between two similar sheets of overlaminate film **38,39** as shown. Overlaminate film is very thin, for example in the range of 0.0015" thick. A book **135** is then constructed for insertion into laminator **40** as is schematically illustrated FIG. **10**. Book **135** comprising core **33**, including at least one layer of ink **36** and at least one layer of overlaminate film **38**, **39** is positioned between laminating plates which are preferably highly polished plates such as mirror finished stainless steel plates **90**, **92**. Book **135** also comprises first and second laminating pads **60**, **62** and first and second steel plates **70**, **72** as is discussed above in relation to FIG. **7**.

When book **135** is positioned between upper and lower platens **42,44** of laminator **40** as shown in FIG. **10**, the laminator is closed and a heat cycle in the range of 175° F. to 300° F., and most preferably in the range of 180° F. to 275° F., is applied to book **135** for a period of 10 to 25 minutes with a ram pressure that varies depending upon sheet size or the ram size of the laminator **40**, but which is typically approximately 1000 p.s.i. with an 18 inch diameter ram. The laminator **40** is then caused to execute a chill cycle, preferably with a corresponding increase in ram pressure. For example, the chill temperature may be in the range of 40° F. to 65° F. and last for a period of 10 to 25 minutes. A ram pressure increase of approximately 25% over the pressure used for the heat cycle has been found to be most preferable.

Subsequent to the above described second lamination cycle as illustrated in FIG. **10**, a sheet of plastic card stock is provided which comprises at least core **33** with at least one surface **34,35** thereof covered by a layer of ink **36**, and with at least one surface **34,35** thereof covered by a layer of overlaminate film **38**, **39**. Preferably plastic card stock manufactured in accordance with the present invention comprises core **33** covered on both surfaces **34,35** with a layer of ink **36** which is positioned between layers of overlaminate film **38,39**, all of which has been laminated together as described. One or more cards **10** then may be cut from the resulting plastic card stock and card **10** will have a thickness in the range of 0.028 inches to 0.032 inches with variation in overall thickness across the surfaces **12**, **14** thereof being no greater than approximately 0.0005 inches. The one or more cards **10** can thus be said to have a surface smoothness of approximately 0.0005 inches or better. Thus, a card **10** manufactured in accordance with the present invention includes at least one surface **12,14** at preferably both surfaces **12,14** that are sufficiently smooth and regular to receive dye sublimation printing.

Those skilled in the art will recognize that the foregoing description has set forth the preferred embodiment of the invention in particular detail and it must be understood that numerous modifications, substitutions, and changes may be undertaken without departing from the true spirit and scope of the present invention as defined by the ensuing claims.

What is claimed is:

1. A process for incorporating at least one electronic element in the manufacture of a plastic card, comprising the steps of:

(a) providing first and second plastic core sheets;

(b) positioning said at least one electronic element in the absence of a non-electronic carrier directly between said first and second plastic core sheets to form a core, said plastic core sheets defining a pair of inner and outer surfaces of said core;

(c) positioning said core in a laminator apparatus, and subjecting said core to a heat and pressure cycle, said heat and pressure cycle comprising the steps of:

(i) heating said core for a first period of time;

(ii) applying a first pressure to said core for a second period of time such that said at least one electronic element is encapsulated by said core;

(iii) cooling said core while applying a second pressure to said core,

(d) coating at least one of said outer surfaces of said core with a layer of ink; and

(e) applying a layer of overlaminate film to at least one of said outer surfaces of said core.

2. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **1**, wherein said laminator apparatus has first and second laminating plates, at least one of said first and second laminating plates having a matte finish for creating a textured surface on at least one of said outer surfaces of said core.

3. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **2**, wherein each of said first and second laminating plates has a matte finish for creating said textured surface on both of said outer surfaces of said core.

4. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **1**, wherein said first and second plastic core sheets are made from a material selected from the group consisting of polyvinyl chloride, polyester, and acrylonitrile-butadiene-styrene, each of said sheets having a thickness in the range of 0.007 to 0.024 inch.

5. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **4**, wherein said first and second plastic core sheets have a thickness of approximately 0.0125 inch.

6. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **1**, wherein said second pressure is greater than said first pressure.

7. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim 6, wherein said second pressure is at least approximately 25% greater than said first pressure.

8. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim 1, wherein said core is heated in step (c)(i) to a temperature in the range of 275° F. to 400° F. and said first period of time is at least five (5) minutes.

9. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim 1, wherein said first pressure is approximately 1000 p.s.i. and said second period of time is at least 10 minutes.

10. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim 1, wherein said step (d) is carried out utilizing a printing press.

11. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim 1, wherein said step (d) is carried out utilizing a coating technique selected form the group consisting of silk screen printing, offset printing, letterpress printing, screen printing, roller coating, spray printing, and litho-printing.

12. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim 1, wherein said step (e) of applying a layer of overlaminate film comprises the further steps of:

(a) positioning an overlaminate film on at least one ink coated surface of said core;

(b) subjecting said core to a second heat and pressure cycle comprising the steps of:

(i) heating said core to a temperature between approximately 175° F. to 300° F. for approximately 10 to 25 minutes;

(ii) applying approximately 1000 p.s.i. pressure to said core; and

(iii) cooling said core to a temperature in the range of approximately 40° F. to 65° F. for approximately 10 to 25 minutes.

13. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim 1, wherein said at least one electronic element is a micro-chip and an associated wire antenna.

14. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim 1, wherein said at least one electronic element is a micro-chip and an associated circuit board antenna.

15. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim 1, wherein said at least one electronic element is a read/write integrated chip and an associated antenna.

16. A hot lamination process for the manufacture of plastic cards, said process comprising the steps of:

(a) providing first and second plastic core sheets;

(b) positioning at least one electronic element in the absence of a non-electronic carrier directly between said first and second plastic core sheets to form a layered core;

(c) positioning said core in a laminator apparatus, and subjecting said core to a heat and pressure cycle, said heat and pressure cycle comprising the steps of:

(i) heating said core in said laminator, in the presence of a minimal first ram pressure, to a temperature which causes controlled flow of said plastic which makes up said first and second plastic core sheets;

(ii) applying a second pressure uniformly across said core for encapsulating said at least one electronic element within said controlled flow plastic;

(iii) subsequently cooling said core in conjunction with the concurrent application of a third pressure uniformly across said core, said core including and upper and lower surfaces;

(d) printing on at least one of said upper and lower surfaces of said core such that a layer of ink is applied to at least a portion of said at least one upper and lower surface of said core.

17. The method as recited in claim 16 wherein said first and second core layers are devoid of any appreciable cut-outs.

* * * * *

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United States Patent [19]

Leighton

[11] Patent Number: 6,036,099

[45] Date of Patent: Mar. 14, 2000

[54] **HOT LAMINATION PROCESS FOR THE MANUFACTURE OF A COMBINATION CONTACT/CONTACTLESS SMART CARD AND PRODUCT RESULTING THEREFROM**

[76] Inventor: **Keith Leighton**, 2817 Fulmer Rd., Lorain, Ohio 44053

[21] Appl. No.: **08/918,582**

[22] Filed: **Aug. 19, 1997**

Related U.S. Application Data

[63] Continuation-in-part of application No. 08/727,789, Oct. 7, 1996.

[51] **Int. Cl.**[7] **G06K 19/02**; G06K 19/06; B32B 31/00; C09S 5/02

[52] **U.S. Cl.** **235/488**; 235/492; 156/182; 156/154; 156/267; 156/311; 156/312

[58] **Field of Search** 235/488, 492, 235/486, 375; 360/2; 156/182, 154, 267, 311, 312

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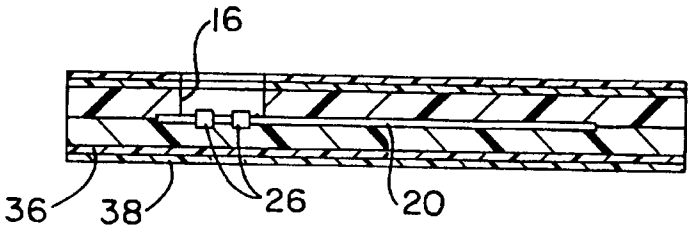
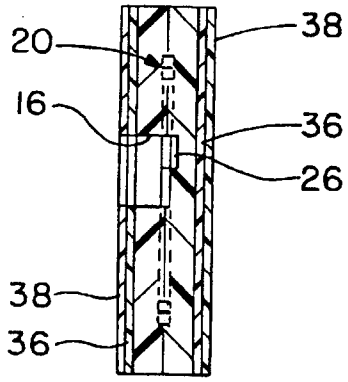
Primary Examiner—Donald Hajec
Assistant Examiner—Daniel Sherr
Attorney, Agent, or Firm—Oldham & Oldham Co., L.P.A.

[57] **ABSTRACT**

A plastic smart card, such as a card having a radio frequency identification (RFID) proximity function, including at least one electronic element embedded therein and a physical contact card function and the hot lamination process for the manufacture of this dual function smart card and other plastic cards including a micro-chip embedded therein. The process results in a card having a preferred overall thickness in the range of 0.028 inches to 0.032 inches with a surface suitable for receiving dye sublimation printing—the variation in card thickness across the surface should not exceed 0.0005 inches. A card manufactured in accordance with the present invention also complies with all industry standards and specifications. Also, the hot lamination process of the present invention results in an aesthetically pleasing card. The invention also relates to a plastic card formed in accordance with the hot lamination process of the present invention.

18 Claims, 4 Drawing Sheets





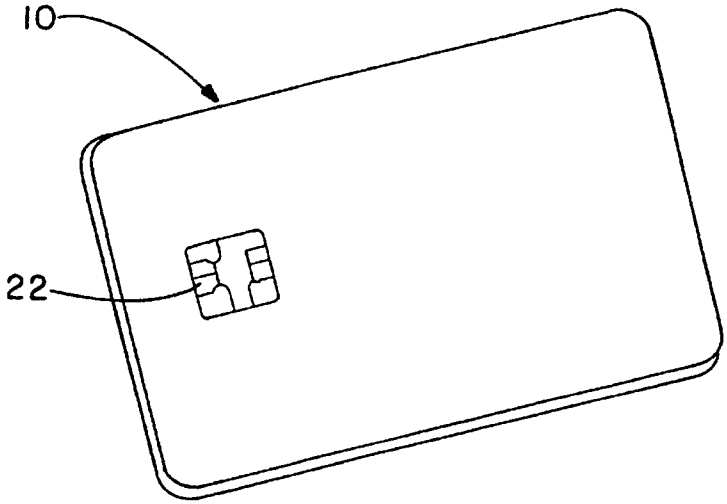


FIG.- 1

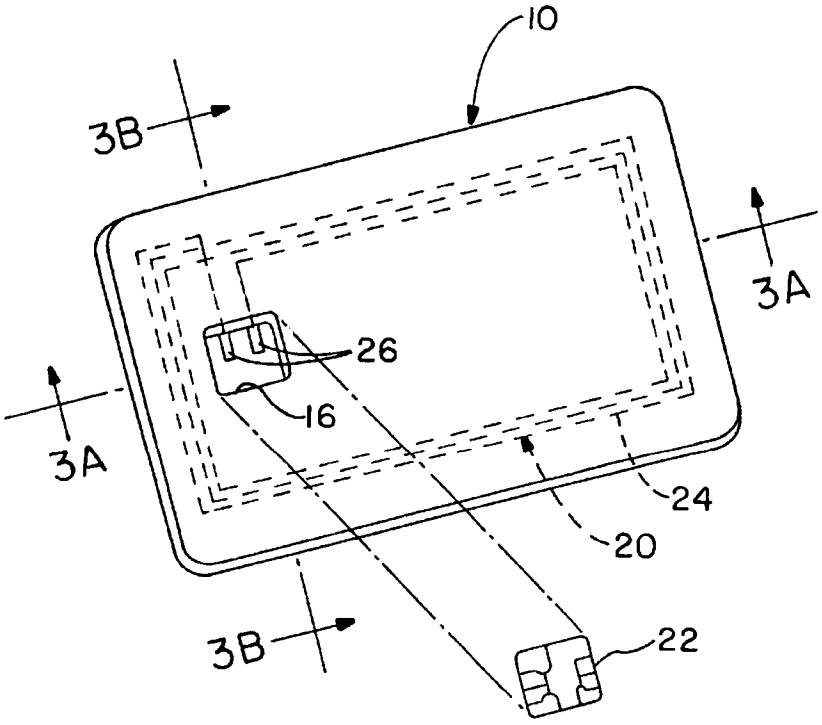


FIG.- 2

FIG.-2A

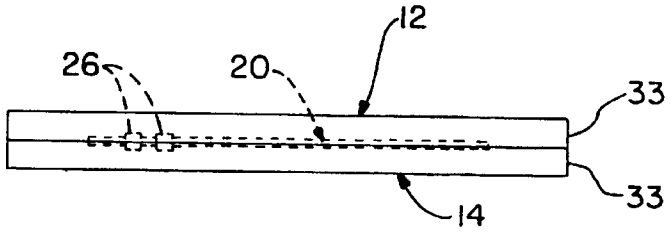


FIG.-3A

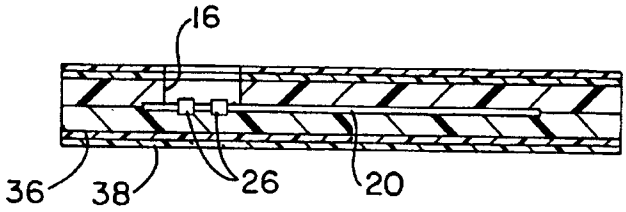
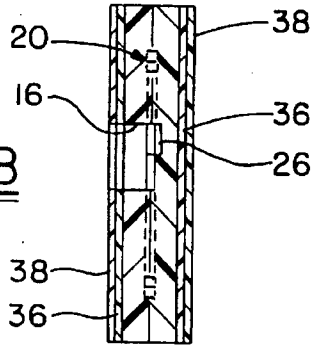


FIG.-3B



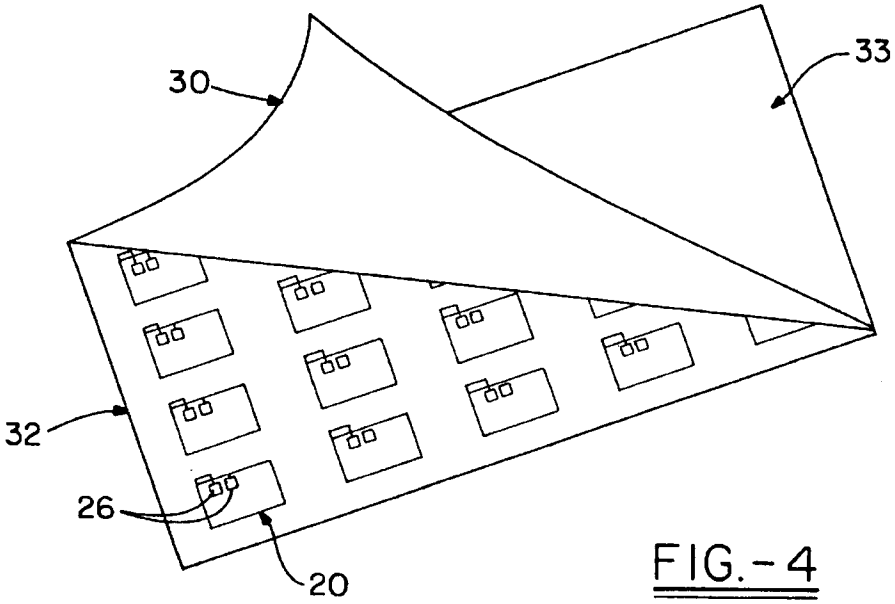


FIG.-4

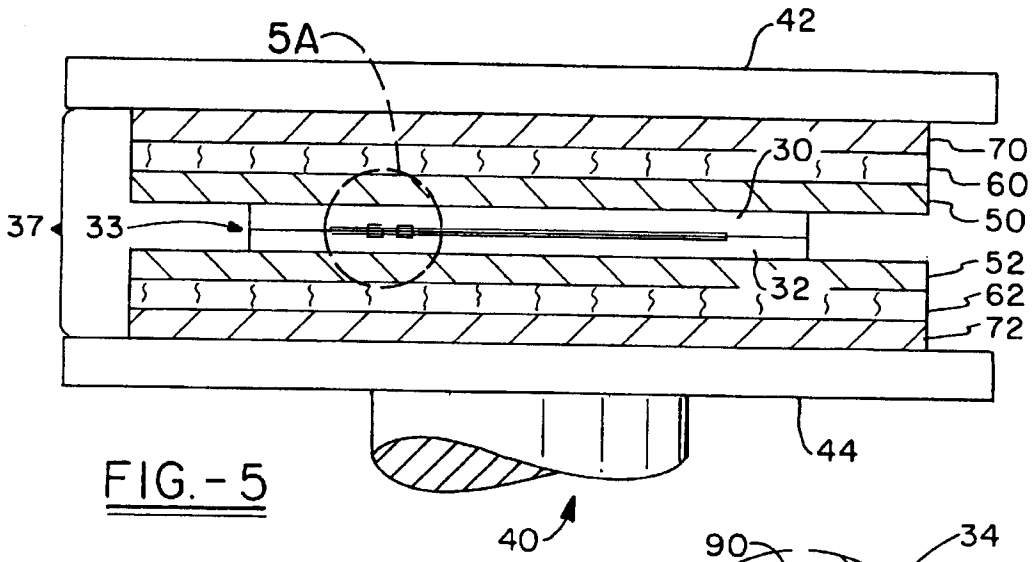


FIG.-5

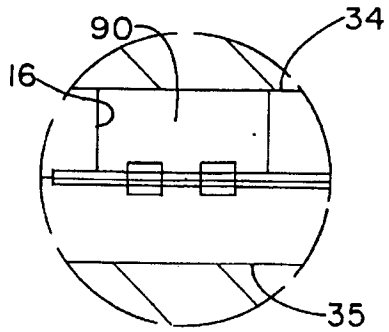


FIG.-5A

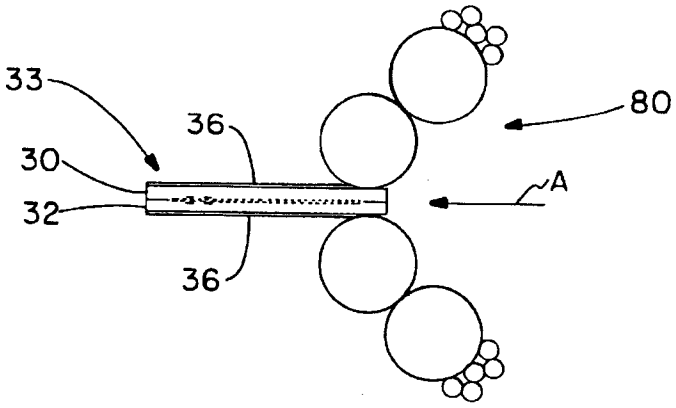


FIG.-6

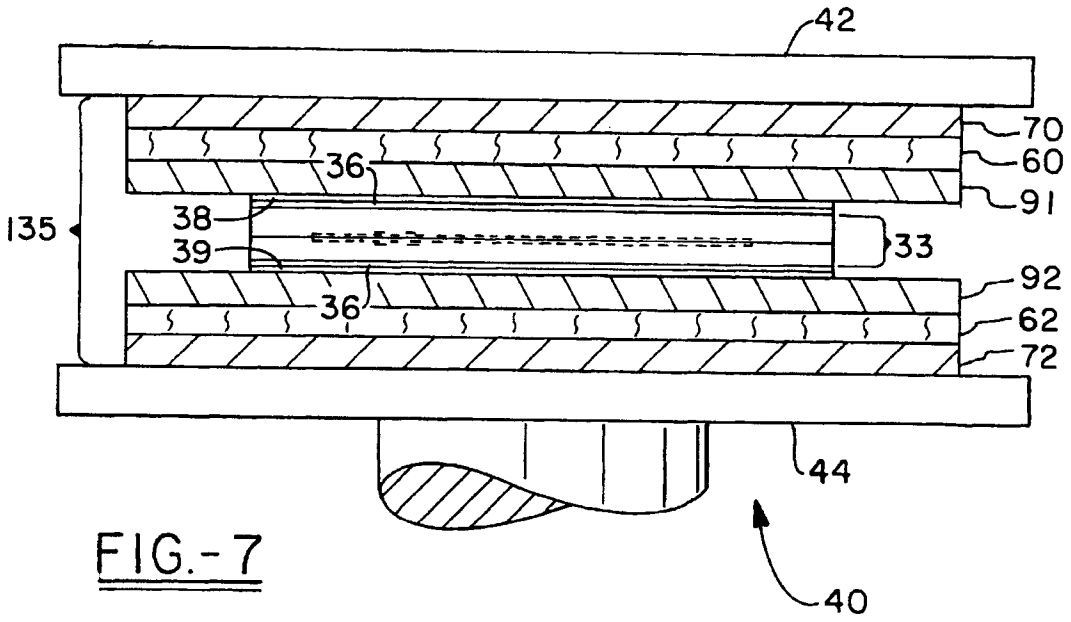


FIG.-7

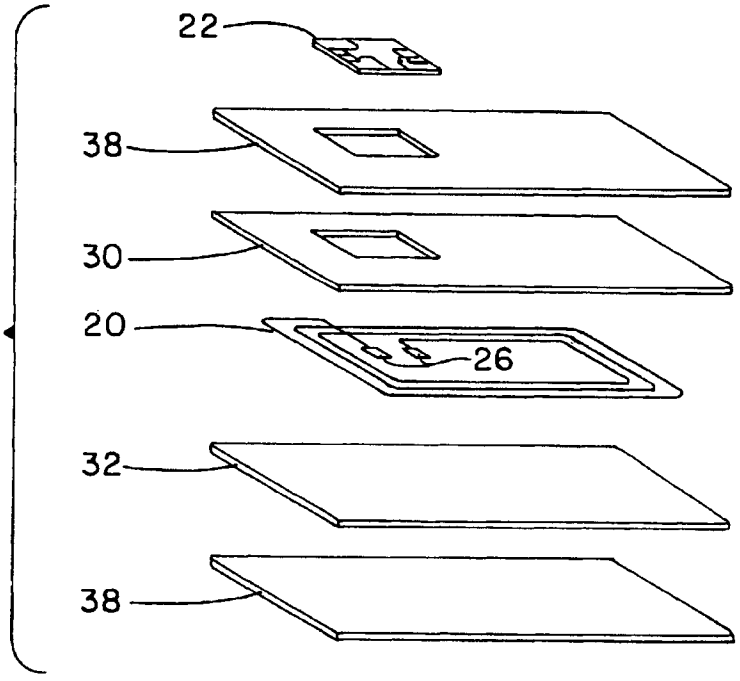


FIG.-8

HOT LAMINATION PROCESS FOR THE MANUFACTURE OF A COMBINATION CONTACT/CONTACTLESS SMART CARD AND PRODUCT RESULTING THEREFROM

This application is a continuation-in-part of copending application Ser. No. 08/727,789 filed Oct. 7, 1996.

FIELD OF THE INVENTION

The present invention relates generally to plastic cards and the manufacture thereof by a hot lamination process, and more particularly to smart cards and the manufacture of these such that they conform to industry size and performance standards and conventions and that have a superior outer surface as compared to known smart cards such that the card may receive dye sublimation printing or the like. Even more specifically, the preferred embodiments of the present invention relate to dual function cards containing imbedded electronic elements as well as an exposed electronic contact surface.

BACKGROUND OF THE INVENTION

As the use of plastic cards for credit cards, automated teller machine (ATM) cards, identification cards, and like continues to become more widespread, the problems associated with the use of such cards correspondingly increase. Credit card fraud and identification card fraud are becoming larger problems everyday, and this fraud has introduced uncertainties into our systems of commerce and our security systems. Using easily available technology, criminals are able to manufacture credit/debit cards, ATM cards, identification cards, and the like having another's account code, identification code, or other personal information embedded in the magnetic stripe thereof. Thus, for example, criminals may steal hundreds or thousands of legitimate credit card account numbers and manufacture many additional cards bearing the stolen information. These fraudulent cards are then usable by the criminals to purchase goods and to receive cash with the legitimate card holder and the card issuer left holding the bill.

Likewise, so called debit cards are becoming increasingly popular. These cards have stored thereon a certain amount of value for which the card owner has previously paid. For example, a subway rider may purchase a card good for X fares, with one fare being deducted from the card each time the owner rides the subway. Criminals have also been able to manipulate the data stored on these cards to defraud the merchants and others.

The ease in which criminals have been able to manufacture and or manipulate known cards results from the existence of the easily altered magnetic stripe storage medium used by known cards. These magnetic stripes are easily programmed and reprogrammed using commonly available technology. Thus, there has been found a need in the plastic card industry to provide a more secure plastic card that is very difficult or impossible to fraudulently manipulate.

The likely successor to magnetic stripe cards is known as a memory or smart card. A smart card can generally be described as a card having an integrated circuit with memory that is capable of making decisions. The category of smart cards can be further divided into subcategories based on the type of memory or type of communication with an associated card reader. Types of smart cards include contact cards (cards requiring physical touch between the terminal reader and the surface of the card) and contactless cards (cards which interact with the terminal reader using a electromagnetic coupling). Contactless cards may also be referred to as "proximity" cards. This technology may serve as a substitute for or be provided as an addition to the magnetic stripe on a card.

One specific type of smart card is a dual function contact/contactless microprocessor chip plastic card commonly referred to in the industry as a dual function card. This card utilizes a single micropressor to control both physical contact and proximity features of the card.

While these smart cards have been found to have infinitely more capability than magnetic stripe cards as well as being more successful in preventing or limiting fraud, they are more difficult and expensive to manufacture relative to ordinary magnetic stripe cards. One of the biggest obstacles to the wide spread manufacture and use of smart cards has been the inability of card manufacturers to manufacturer a smart card that meets all industry standards and specifications, such as those set by the International Standards Organization (ISO), that are sufficiently aesthetically pleasing (wherein the embedded electronics are hidden from view), and that have a sufficiently regular or flat surface such that one or both surfaces of the card may be printed on using the very popular and widespread dye sublimation technology.

Limitations to known plastic cards with embedded computer chips and electronics are that they a) are too thick to work in connection with existing card reading machinery (ATM machines, telephones, b) have a surface that is too irregular to properly and consistently receive dye sublimation printing, c) utilize manufacturing processes making the cards cost prohibitive. Moreover, prior attempts to manufacture a sufficiently thin plastic card including a computer chip embedded therein have resulted in a card with inferior aesthetic qualities such as the ability to see the embedded computer chip through the plastic.

Furthermore, due to the presence of both internal and surface electronics within the card, the manufacture of a dual function card presents its own unique set of obstacles and problems, different from the manufacture of cards with fully embedded electronics.

SUMMARY OF THE INVENTION

The present invention is therefore directed to a hot lamination method for the manufacture of a plastic card having at least one electronic element embedded therein as well as at least one electronic element with an exposed contact surface and to such plastic cards. The card has an overall thickness in the range of 0.028 inches to 0.032 inches and comprises a plastic core having at least one electronic element embedded therein with at least one of the upper and lower surfaces of the core comprising a coating printed or otherwise applied thereon. A portion of the card's outer surface exposes a contact surface electronic element operatively connected to the card's internal electronics. An overlaminate film is preferably provided over the coated surface of the core and the resulting card has a variation in thickness across the surfaces thereof of no greater than approximately 0.0005 inches.

The hot lamination method of the present invention comprises the steps of providing upper (first) and lower (second) plastic core sheets, positioning at least one electronic element between the first and second core sheets to thus form a core, and placing the core in a laminator and closing the laminator with minimal or no laminator ram pressure applied to the core. A heat cycle is applied to the core sheets in the laminator to cause complete or partial flow

of the plastic sheets. The laminator ram pressure is then increased in combination with the heat. A cooling cycle is then applied to the core in the laminator, preferably with an associated increase in ram pressure, and the core is removed from the laminator.

In the preferred embodiment, the laminated core next undergoes a controlled depth milling operation to expose one or more contact pads which comprise part of the internal, embedded electronic element.

In alternative embodiments, one of the plastic sheets contained a pre-formed window which is positioned over the contact pads, prior to lamination. A spacer, integral to the corresponding platen or separate therefrom, is utilized to prevent or limit the flow of plastic into the window region so as not to coat the contact pads with plastic during the card manufacturing process.

At least one surface of the core is then printed on using a printing press or similar printing apparatus, a sheet of overlaminate film is placed on at least one side of the core, and the core is once again placed in a laminator. A heat cycle is applied to the core with its overlaminate film, and a cooling cycle is thereafter applied, resulting in a sheet of plastic card stock from which one or more cards may be cut.

Contact surface elements are installed into the window region of a plastic card and in operable contact with contact pads.

The invention is also directed to a card manufactured in accordance with the above process which results in a plastic card having a thickness in the range of approximately 0.028 inches to 0.032 inches with a surface smoothness of at least approximately 0.0005 inches as is required by International Standards Organization (ISO) and American National Standards Institute (ANSI) standards.

The present invention provides numerous advantages over known plastic cards and known plastic card manufacturing processes, and includes the formation of a plastic card with electronic elements such as a computer chip embedded therein with a pleasing aesthetic appearance, having a sufficiently smooth and regular surface such that the card may receive dye sublimation printing, and possessing sufficient durability and characteristics to comply with all industry specifications and standards.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a plastic card in accordance with the present invention;

FIG. **2** is a perspective view of the card shown in FIG. **1**, illustrating the embedded and exposed electronics incorporated into the card;

FIG. **2A** is a side elevational view of the card core illustrating various electronic elements that may be embedded in a card in accordance with the present invention;

FIG. **3A** is a cross sectional view of the card illustrated in FIG. **2**, taken through section line **3A—3A**.

FIG. **3B** is a cross sectional view of the card illustrated in FIG. **2**, taken through section line **3B—3B**.

FIG. **4** is a perspective view of a plurality of electronic elements positioned on a sheet of plastic core stock and covered by a second sheet of plastic core stock.

FIG. **5** is a schematic cross sectional view illustrating a book comprising the core, containing electronics, as positioned in a laminator;

FIG. **5A** is an enlarged cross-sectional view of the portion encircled in FIG. **5** for an alternative embodiment, utilizing a spacer, for producing a card according to the present invention;

FIG. **6** schematically illustrates the process of printing on the core;

FIG. **7** is a schematic cross sectional view illustrating the core with overlaminate film, as placed in a laminator;

FIG. **8** is an exploded view of a plastic card produced by the process of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to a plastic card including at least one electronic element embedded therein. The present invention also relates to a hot lamination process for the manufacture of plastic cards, and more particularly to a hot lamination process for the manufacturer of plastic cards that include an electronic element, such as a computer chip or other electronic element embedded therein. The electronic element may perform a wide variety of functions and take a wide variety of forms. Such cards, without regard to the particular electronic element embedded therein, will hereinafter be referred to as smart cards. The present invention also relates to a card formed in accordance with the invention.

In its preferred embodiment and as illustrated in FIGS. **1** and **2**, the present invention relates to the manufacture of a dual function card, a particular type of smart card which utilizes a dual function contact/contactless microprocessor chip, as described previously herein. However, it will be appreciated by those skilled in the art, that the method of hot lamination described herein could easily be applied to other identity card or smart card applications.

Referring now to FIGS. **1**, **2**, and **2A** there can be seen a plastic card **10** manufactured in accordance with the present invention and including an electronic element, generally **20**, embedded therein. Card **10** includes an upper surface **12** and a lower surface **14**. Electronic element **20** may take a wide variety of forms (microprocessor chip, circuit board, transponder, etc.) and perform a wide variety of functions. As shown in FIGS. **2**, **2A**, and **3A**, , electronic element **20** may comprise a read/write micro-chip **22** including a wire antenna **24** connected thereto, any other suitable electronic element. These electronic elements **20**, **22** and **24** and their insertion into plastic cards is not new, however, the present invention provides a new hot lamination process for manufacturing plastic cards **10** with these electronic elements embedded therein such that the cards **10** are of a superior quality, meet all ISO and other industry specifications and standards, and are sufficiently smooth and otherwise is capable of receiving dye sublimation printing. Electronic elements such as these described are available from manufacturers such as Motorola and Philips Electronics.

Upper surface **12** contains a window or cavity **16** formed therein and intended to expose one or more contact pads **26** operatively connected to antenna **24**. Upon formation of card **10** in accordance with the preferred embodiment, a microprocessor chip **22** is inserted into window **16** and in electrical connection with contact pads **26**. This microprocessor chip may function as a "proximity" or radio frequency identification (RFID) card in conjunction with antenna **24** when electromagnetically used with a compatible terminal reader. Microprocessor chip **22** is also capable of function as a contact card, requiring physical contact between a compatible terminal reader and the surface of chip **22**. It should be appreciated that the contact function of the card may be accomplished by any contact sensor whether integral to or physically separate from chip **22** and that window **16** may be formed anywhere on surfaces **12** and/or **14** as will accomplish the purposes of the invention.

Specifically, a card in accordance with the present invention has a thickness of approximately in the range of 0.028 inches to 0.032 inches with a surface smoothness of 0.0005 inches. In order to meet the ISO standards for such cards, these tolerances apply to the surface of the microprocessor chip **22** surface as well as to the surface of plastic portion of card **10**. It is to be appreciated that cards having a thickness greater than 0.032 inches can easily be manufactured in accordance with the teachings herein while meeting all of the other criteria of the present invention. However, the foreseen product demand is for cards meeting the aforementioned standards.

As shown in FIG. **4**, one or more cards **10** in accordance with the present invention may be manufactured by positioning an electronic element **20**, including contact points **26**, between first and second sheets of card stock **30, 32** to form a core **33**. Preferably as shown, a plurality of cards are manufactured simultaneously, and accordingly a plurality of electronic elements **20** are positioned between the first and second sheets of plastic core stock **30, 32**. When a plurality of electronic elements **20** are positioned between first and second sheets plastic core stock **30, 32**, electronic elements **20** are property positioned relative to one another such that a plurality cards may be cut from the resulting card stock.

Plastic core sheets **30, 32** may be provided by a wide variety of plastics, the preferred being polyvinyl chloride (PVC) having a thickness in the range of 0.007 inches to 0.024 inches and preferably having a thickness of approximately 0.0125 inches each. Those skilled in the art will recognize that the thickness of the plastic core sheets will depend somewhat upon the thickness of the one or more electronic elements that are to be embedded therebetween if ISO standards are intended to be met. Other suitable plastics that may be utilized include polyester, acrylonitrile-butadiene-styrene (ABS), and any other suitable plastic.

Subsequent to placing one or more electronic elements **20** between the first and second sheets **30, 32** of plastic core stock to form a core **33**, this core **33** is placed in a laminator apparatus **40** of the type well known in the art of plastic card manufacturing. As is shown in FIG. **5**, laminator **40** includes upper and lower platens **42,44** for applying ram pressure to an article positioned therebetween. In addition to the ability to apply ram pressure, laminator **40** is preferably of the type having controlled platens **42,44** that may provide both heat and chill cycles and preferably includes cycle timer to regulate cycle time. Core **33** is positioned between first and second laminating plates **50, 52**, one of which is preferably matte finished to provide laminated core **33** with at least one textured outer surface. First and second laminating pads **60, 62** are positioned outside of the laminating plates **50, 52**, and first and second steel plates **70, 72** are likewise positioned outside of pads of **60, 62** and the entire assembly forms a book **35** for being positioned in laminator **40** between platens **42, 44**.

Once book **35** is positioned in laminator **40** as shown in FIG. **5**, the first lamination cycle is initiated by closing laminator platens **42, 44**, preferably applying little or no ram pressure to book **35**. This is preferably done using hydraulic pressure, and a pressure not to exceed about 10 pounds per square inch is believed sufficient for most applications.

A laminator heat cycle is initiated, bringing the temperature of platens **42,44** up to a range of 275° F. to 400° F., and most preferably up to a range of 300° F. to 370° F. for a period of ranging between 1 to 20 minutes, but preferably greater than 5 minutes, and most preferably in the range of 7 to 10 minutes for PVC material. It must be understood that the temperatures recited herein are by means of example. The use of thermoplastic material other than PVC or the presence of pigments in the core material may require modification of the heat cycle temperature.

Once the heat cycle has been applied to book **35** as is set forth above, the ram pressure of laminator **40** is increased to facilitate the flow of the plastic core sheets **30, 32** so that the one or more electronic elements **20** become encapsulated thereby, and so that sheets **30, 32** form a uniform core **33** with upper and lower surfaces **34,35**. The ram pressure translates into an effective pressure on core **33** in the range of 200 to 450 psi and preferably in the range of 250 to 350 psi. As can be expected temperature and pressure are inversely related to one another. In other words a lamination cycle at a higher temperature will require less pressure to be applied to core **33**, and conversely a lower temperature heat cycle will require increased ram pressure. Damage to the electronic components can result from excessive ram pressure on the core while insufficient ram pressure will likely cause an inadequate flow of the plastic resulting in air pockets or an irregular card surface.

As mentioned, the use of matte finished laminator plates **50,52** provides surfaces **34,35** with a slightly roughened or textured quality which will facilitate the application of a coating thereto as is discussed below. The ram pressure applied during the heat cycle and the length of the heat cycle may vary, depending especially upon the size of sheets **30, 32**. For example, the cycle time may be in the range of 10–15 minutes. In one example, at a temperature of approximately 320 degrees Fahrenheit, a ram pressure of 940.135 pounds per square inch (p.s.i.), producing a pressure of about 275 psi at the core **33** surface, was applied for 10–15 minutes to form a uniform core **33**, using sheets **30,32** of a size in the range of 12 inches by 24 inches to 24 inches by 36 inches.

Subsequent to the above heat cycle, laminator **40** applies a chill cycle to book **35** during which time the ram pressure of the laminator **40** is increased, preferably by approximately 10–40% and most preferably about 25% until the platens **42,44** have cooled so as to return the core material to a solid state. In the preferred method the platens **42, 44** are cooled to approximately 40° F. to 65° F. for approximately 10–15 minutes. Core **33** may then be removed from laminator **40** for additional processing.

Subsequent to the removal of core **33** from laminator **40**, and as illustrated in FIG. **6**, core **33** is coated on at least one of its upper and lower surfaces **34, 35** with a layer of printing ink **36**. This may be accomplished using a wide variety of printing techniques such as offset printing, letterpress printing, screen printing, roller coating, spray printing, lithoprinting, and other suitable printing techniques. As shown in FIG. **6**, core **33** is fed in the direction indicated with arrow A through a printing press, a lithographic printer, or a similar apparatus **80**. This printing step is performed to coat at least one surface **34, 35** of core **33** with a layer of aesthetically pleasing ink **36**. This layer of ink **36** can also serve to cosmetically hide the one or more electronic elements **20** that are embedded within core **33**, and prevent these one or more electronic elements **20** from showing through the relatively thin core **33**. In this manner, the one or more electronic elements **20** encapsulated in core **33** are completely hidden from view without requiring the plastic used in the manufacture core **33** to be excessively thick (exceeding ISO standards for cards of this type).

Referring now to FIG. **7**, the final preferred, but optional processing of core **33**, which now comprises a layer of ink **36** or the like on at least one surface **34,35** thereof, is

schematically illustrated. An overlaminate layer such as clear overlaminate film **38** is positioned on at least one ink coated surface **34,35** of core **33**, and preferably core **33** is positioned between two similar sheets of overlaminate film **38,39** as shown. Overlaminate film is very thin, for example in the range of 0.0015" thick. A book **135** is then constructed for insertion into laminator **40** as is schematically illustrated in FIG. **7**. Book **135** comprising core **33**, including at least one layer of ink **36** and at least one layer of overlaminate film **38, 39** is positioned between laminating plates which are preferably highly polished plates such as mirror finished stainless steel plates **91, 92**. Book **135** also comprises first and second laminating pads **60, 62** and first and second steel plates **70, 72** as is discussed above in relation to FIG. **7**.

When book **135** is positioned between upper and lower platens **42,44** of laminator **40** as shown in FIG. **7**, the laminator is closed and a heat cycle in the range of 175° F. to 300° F., and most preferably in the range of 180° F. to 275° F., is applied to book **135** for a period of 10 to 25 minutes to produce a pressure on book **135** of between 200 to 450 psi, preferably 250–350 psi, with a ram pressure that varies depending upon sheet size or the ram size of the laminator **40**, but which is typically approximately 1000 p.s.i. with an 18 inch diameter ram. This step causes the overlaminate layer **38** to flow in order to produce a uniform protective layer over the printing.

The laminator **40** is then caused to execute a chill cycle, preferably with a corresponding increase in ram pressure. For example, the chill temperature may be in the range of 40° F. to 65° F. and last for a period of 10 to 25 minutes. However, any combination of temperature and time which permits the re-solidification of the overlaminate layer **38** may be used. A ram pressure increase of approximately 10 to 40% over the pressure used for the heat cycle has been found to be preferable, with a pressure increase of approximately 25% being most desirable.

It is important to note that the use of pressure, or more significantly temperature, in the second lamination cycle should only affect the overlaminate layer **38** and should not cause softening or re-flow of plastic core **33**. In lieu, of this preferred overlamination process, it is to be understood that colorfast inks may not require an overlaminate layer or that alternative overlaminates such as those applied by spray, silk screening or roll on may be used.

Subsequent to the above described second lamination cycle, a sheet of plastic card stock is provided which comprises at least core **33** with at least one surface **34,35** thereof covered by a layer of ink **36**, and with at least one surface **34,35** thereof covered by a layer of overlaminate film **38, 39**.

Preferably plastic card stock manufactured in accordance with the present invention comprises core **33** covered on both surfaces **34,35** with a layer of ink **36** which is positioned between layers of overlaminate film **38,39**, all of which has been laminated together as described and as shown in FIG. **8**. One or more cards **10** then may be cut from the resulting plastic card stock and card **10** will have a thickness in the range of 0.028 inches to 0.032 inches with variation in overall thickness across the surfaces **12, 14** thereof being no greater than approximately 0.0005 inches. The one or more cards **10** can thus be said to have a glossy surface smoothness of approximately 0.0005 inches or better. Thus, a card **10** manufactured in accordance with the present invention includes at least one surface **12,14** at preferably both surfaces **12,14** that are sufficiently smooth, glossy and regular to receive dye sublimation printing.

In the preferred embodiment, each card **10** undergoes a controlled-depth milling operation to form a window or cavity **16** and to expose one or more of the contact pads **26** connected to the antenna **24**. Thereafter, a microprocessor chip **22** having a contact surface is inserted into the cavity and in electronic contact with contact pads **26**. Chip **22** may be attached to contact pads **26** by known means such as conductive adhesives (including those cured by UV or sonic energy) or low temperature solder. The overall thickness of the card including the area occupied by chip **22** meets ISO standards and is capable of operation in compatible physical readers.

In an alternative embodiment, a cavity or window **16** is formed in the first or second sheet of plastic core stock, prior to the first lamination step. The core stock is positioned over the electronic element, generally **20**, to expose one or more contact pads **26**. This may also be done using electronic elements wherein microprocessor chip **22** is already attached to contact pads **26** and/or antenna **24** in which case the cavity is positioned over and around chip **22**. As shown in FIG. **5*a***, a spacer **90** is inserted into cavity **16** and over contact pads **26** or chip **22**. The spacer **90** may be integral to one of the matte laminating plates **50, 52** or separate therefrom and made of any suitable non-stick material such as Teflon™ Spacer **90** is utilized to prevent or limit the flow of plastic into cavity **16** during the lamination process so as not to cover contact pads **26** or chip **22** with plastic. When spacer **90** is non-integral with matte laminating plate **50** or **52** it may be removed or cut-away after either the lamination or overlamination process to expose cavity **16** and allow microchip **22** to be inserted therein and retained by such means as are known in the art, including solder or adhesives. In this embodiment where the chip is installed prior to lamination, when viewed in cross-section the outer surface of chip **22** is below the upper surface **34** or core sheet **35** prior to lamination, thus core sheets will accept the majority of applied pressure from the laminator. Spacer **90** provides further protection. As the core material softens, the plastic will flow around spacer **90** and chip **22** and the distance between the outer surface of chip **22** and the upper surface of core sheet **35** will decrease.

Those skilled in the art will recognize that the foregoing description has set forth the preferred embodiment of the invention in particular detail and it must be understood that numerous modifications, substitutions, and changes may be undertaken without departing from the true spirit and scope of the present invention as defined by the ensuing claims.

What is claimed is:

1. A process for incorporating at least one electronic element in the manufacture of a plastic card, comprising the steps of:

(a) providing first and second plastic core sheets;

(b) positioning said at least one electronic element in the absence of a non-electronic carrier directly between said first and second plastic core sheets to form a core, said plastic core sheets defining a pair of inner and outer surfaces of said core;

(c) positioning said core in a laminator apparatus, and subjecting said core to a heat and pressure cycle; said heat and pressure cycle comprising the steps of:

(i) heating said core for a first period of time;

(ii) applying a first pressure to said core for a second period of time such that said at least one electronic element is encapsulated by said core;

(iii) cooling said core while applying a second pressure to said core;

(d) coating at least one of said outer surfaces of said core with a layer of ink;

(e) milling a region of said core to a controlled depth so as to form a cavity which exposes at least one contact pad of said electronic element.

2. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **1**, wherein said laminator apparatus has first and second laminating plates, at least one of said first and second laminating plates having a matte finish for creating a textured surface on at least one of said outer surfaces of said core.

3. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **2**, wherein each of said first and second laminating plates has a matte finish for creating said textured surface on both of said outer surfaces of said core.

4. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **1**, wherein said first and second plastic core sheets are made from a material selected from the group consisting of polyvinyl chloride, polyester, and acrylonitrile-butadiene-styrene, each of said sheets having a thickness in the range of 0.007 to 0.024 inch.

5. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **5**, wherein said first and second plastic core sheets have a thickness of approximately 0.0125 inch.

6. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **1**, wherein said second pressure is greater than said first pressure.

7. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **6**, wherein said second pressure ranges from about 10% to about 40% greater than said first pressure.

8. A hot lamination process as recited in claim **1** having a further step following step (d), said step comprising: positioning said core in a laminator apparatus with a layer of overlaminate film on at least one of said upper and lower surfaces of said core and laminating said layer of overlaminate film to said core in said laminator to thereby form a sheet of plastic card stock.

9. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **1**, wherein said core is heated in step (c)(i) to a temperature in the range of 275° F. to 400° F. and said first period of time is at least five (5) minutes.

10. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **1**, wherein said first pressure is approximately 450 p.s.i. and said second period of time is at least 10 minutes.

11. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **1**, wherein said step (d) is carried out utilizing a printing press.

12. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **1**, wherein said step (d) is carried out utilizing a coating technique selected form the group consisting of silk screen printing, offset printing, letterpress printing, screen printing, roller coating, spray printing and litho-printing.

13. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **1**, wherein said step (e) of applying a layer of overlaminate film comprises the further steps of:

(a) positioning an overlaminate film on at least one ink coated surface of said core;

(b) subjecting said core to a second heat and pressure cycle comprising the steps of:

(i) heating said core to a temperature between approximately 175° F. to 300° F. for approximately 10 to 25 minutes;

(ii) applying approximately 1000 p.s.i. pressure to said core; and

(iii) cooling said core to a temperature in the range of approximately 40° F. to 65° F. for approximately 10 to 25 minutes.

14. A hot lamination process is recited in claim **1** comprising the further step of inserting an electronic contact element into said cavity.

15. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **1**, wherein said at least one electronic element is a micro-chip and an associated circuit board antenna or an associated wire antenna.

16. The process for incorporating at least one electronic element in the manufacture of a plastic card as recited in claim **1**, wherein said at least one electronic element is a read/write integrated chip and an associated antenna.

17. A process for incorporating at least one electronic element having at least one electronic subcomponent in the manufacture of a plastic card, comprising the steps of:

(a) providing first and second plastic core sheets, at least one core sheet having a cavity formed therein;

(b) positioning said at least one electronic element in the absence of a non-electronic carrier between said first and second plastic core sheets to form a layered core, said plastic core sheets defining a pair of inner and outer surface of said core, and said cavity positioned so as to expose said at least one electronic subcomponent therein;

(c) inserting a spacer into said cavity, said spacer substantially filling said cavity and covering said at least one electronic subcomponent;

(d) positioning said core in a laminator apparatus, and subjecting said core to a heat and pressure cycle, said heat and pressure cycle comprising the steps of:

(i) heating said core for a first period of time;

(ii) applying a first pressure to said core for a second period of time such that said at least one electronic element is encapsulated by said core;

(iii) cooling said core while applying a second pressure to said core;

(e) coating at least one of said outer surfaces of said core with a layer of ink;

(f) removing said spacer from the cavity of said core.

18. A hot lamination process as recited in claim **17**, wherein said electronic sub-component comprises one or more elements from the group consisting of a micropressor chip, a contact pad, a transponder and a contact sensor.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,036,099
DATED : March 14, 2000
INVENTOR(S) : Keith R. Leighton

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 1,
Line 7, replace "Oct. 7, 1996" with -- Oct. 7, 1996, which claimed the benefit of provisional application serial no 60/005,685, filed on October 17, 1995, filed on October 17, 1995. This application claims the benefit of provisional application serial no. 60/024,255, filed August 21, 1996 --.

Signed and Sealed this

Twenty-fourth Day of September, 2002

Attest:

Attesting Officer

JAMES E. ROGAN
Director of the United States Patent and Trademark Office

US006248199B1

(12) **United States Patent**
Smulson

(10) **Patent No.: US 6,248,199 B1**
(45) **Date of Patent: Jun. 19, 2001**

(54) **METHOD FOR THE CONTINUOUS FABRICATION OF ACCESS CONTROL AND IDENTIFICATION CARDS WITH EMBEDDED ELECTRONICS OR OTHER ELEMENTS**

(75) Inventor: **Joel R. Smulson**, Calabasas, CA (US)

(73) Assignee: **Soundcraft, Inc.**, Chatsworth, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/299,944**

(22) Filed: **Apr. 26, 1999**

(51) **Int. Cl.**[7] **B29C 47/02**
(52) **U.S. Cl.** **156/244.12**; 156/244.19; 156/298
(58) **Field of Search** 156/242, 243, 156/244.11, 244.12, 244.19, 150, 151, 290, 293, 298, 500, 552; 257/679; 264/272.11, 272.14, 272.17, 279.1

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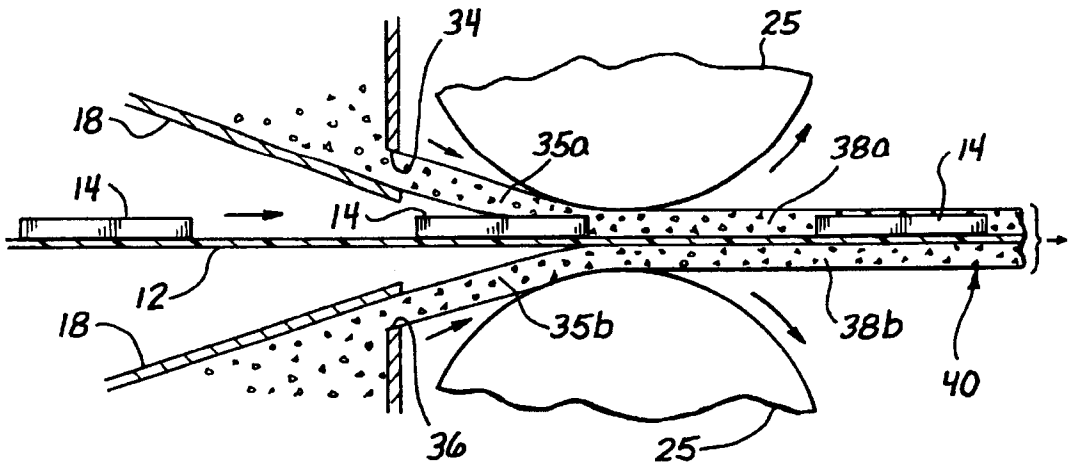
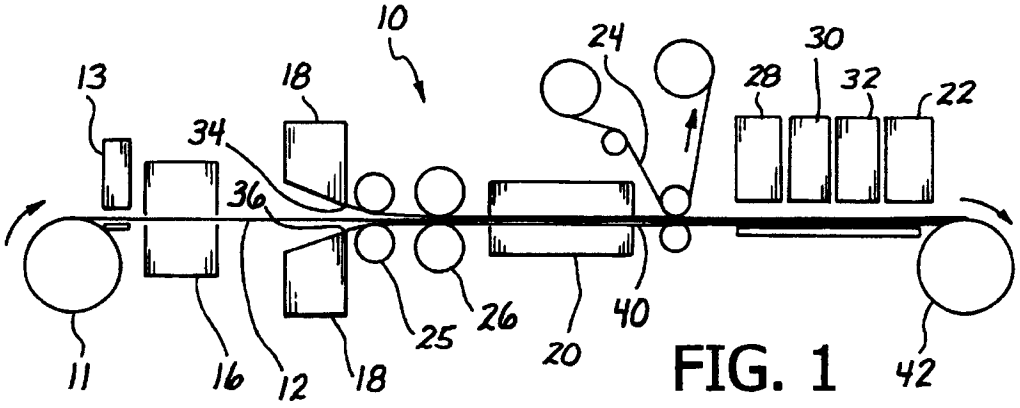
(57) **ABSTRACT**

Cards, labels and the like containing embedded microcircuits or other elements are fabricated in a continuous process by introducing microcircuits between ribbons of extruded material, pressing the ribbons into adhesion with each other while in a plastic state thereby to make a continuous composite sheet containing the microcircuits, cooling the composite sheet to solidify the extrudate material, and cutting out cards from the composite sheet, each card containing a microcircuit. The microcircuits may be introduced between the extruded ribbons on a continuous carrier sheet which may also serve as a printed circuit substrate for the microcircuits. Alternatively, the microcircuits are inserted as discrete units between the extruded ribbons by a suitable robotic device.

1 Claim, 3 Drawing Sheets

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42

FIG. 1

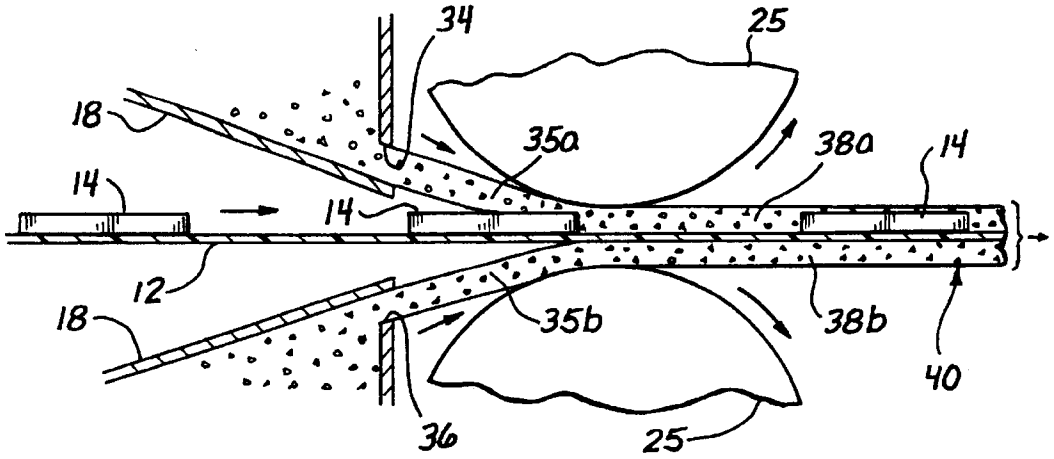
34
25
18
35a
38a
14
14
14
12
18
35b
38b
40
36
25

FIG. 2